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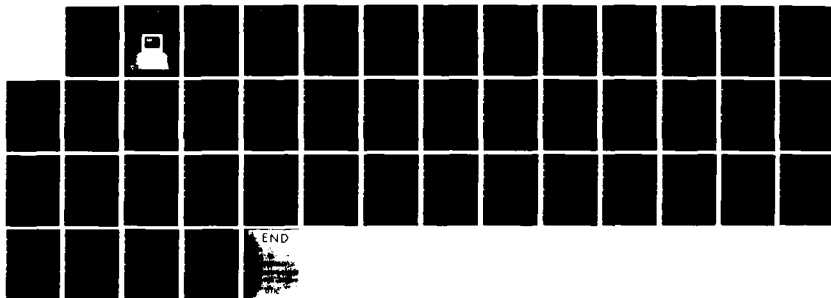
COMPUTER MODEL FOR ECONOMIC STUDY OF UNBLEACHED KRAFT
PAPERBOARD PRODUCTION(U) FOREST PRODUCTS LAB MADISON WI
P J INCE AUG 84 FSGTR-FPL-42

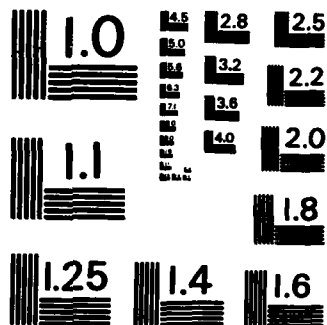
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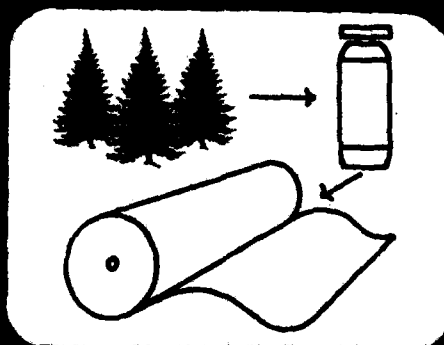
General
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FPL 42

Computer Model for Economic Study of Unbleached Kraft Paperboard Production

Peter J. Ince

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Abstract

Unbleached kraft paperboard is produced from wood fiber in an industrial papermaking process. A highly specific and detailed model of the process is presented. The model is also presented as a working computer program. A user of the computer program will provide data on physical parameters of the process and on prices of material inputs and outputs. The program is then used to calculate material and energy requirements of the process, and to calculate related revenues and variable costs. The program does not derive capital costs or fixed costs. The program is most useful in estimating precisely the economic impact of changes in physical parameters of the process, changes in technology, or changes in related prices. As such, the model can be used to estimate the economic effect, on revenues and costs, of technological changes or changes in prices.

Keywords: Economics, technology, unbleached kraft, paperboard, process, computer model.

Foreword

The computer model described in this report was developed entirely at the Forest Products Laboratory, on the University of Wisconsin's UNIVAC 1110 computing system. The program is written in standard ANSI FORTRAN language. A prospective user should at least have (1) some basic experience or familiarity with FORTRAN computer language and (2) a good working knowledge of parameters in the model, which are the major parameters in an unbleached kraft paperboard production process.

August 1984

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The Laboratory is maintained in cooperation with the University of Wisconsin.

Acknowledgment

Cherilyn A. Hatfield, statistical assistant at the Forest Products Laboratory, transcribed the program, added many program statements necessary to run the program, and was largely responsible for debugging the program and checking for statistical accuracy.

Computer Model for Economic Study of Unbleached Kraft Paperboard Production

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Introduction

Unbleached kraft paperboard is produced from wood fiber in fairly complex industrial papermaking processes, typically in large paperboard mills. Such mills usually include a wood preparation area, a kraft digester, a chemical recovery process, a paper machine, steam and power system, and related facilities. Various publications and texts describe these processes.¹ Overall, in modern conventional mills there is a general similarity in process design and equipment configuration.

Because the production process is complex, any changes in supplies, equipment, or design may have far-reaching effects on material and energy requirements, and costs and revenues. We have designed a computer model to calculate those material and energy requirements of the unbleached kraft paperboard process and to estimate the associated revenues and variable costs. This paper describes that model.

¹The Technical Association of the Pulp and Paper Industry (TAPPI) has recommended texts on these processes, of which two are:

Joint Textbook Committee of the Paper Industry. Pulp and Paper Manufacture Series, Vol. I, II, and III. 2d ed. (MacDonald, Ronald G., ed.; Franklin, John J., technical ed.) McGraw-Hill, New York; 1969. (Available from Tappi.)

Casey, James P., ed. Pulp and Paper, Vol. I, II, and III. Wiley Interscience, New York; 1968.

The computer model uses a set of data consisting of about 180 physical variables of the process and also prices of various inputs and outputs. (It does not include capital costs or fixed costs, such as administrative overhead or maintenance.) The data include major process variables as well as many minor variables. As a result, the user is able to develop an understanding of the sensitivity of results to specific changes in the process. For example, the model can be used to study the potential economic impact of a specific new technological development. First, given a set of data that represent a "conventional" process, the user can operate the model on those data to obtain "base case" results, the conventional process material and energy requirements, revenues and variable costs. The user can then adjust all data variables that are likely to change as a result of the new technological development. The user can then again operate the model using the adjusted variables as data to obtain new results, new material and energy requirements, and new revenue and variable cost estimates. Results can be compared to the base case results to provide an understanding of the physical and economic impact of the new technology. Such results are useful in planning research, setting research goals and priorities, and in evaluating the economic potential of results of technical research and developments in pulping and papermaking.

Scope of Model

The computer model is a detailed representation of a modern unbleached kraft paperboard production process. A general diagram of the process is shown in figure 1. The model itself consists of nine separate elements or subroutines. The subroutines are as follows, in the order in which they are referenced by the main program:

- STPREP, which models stock preparation, additives, paper machine, finishing, and shipping areas of the process;
- DIG, which models the digester, pulp washers, black liquor evaporators, and concentrators area of the process;
- WDPREP, which models the wood preparation, debarking, chipping, and chip-screening area of the process;
- RECBLR, which models the recovery boiler, lime kiln, and recausticizing area of the process;
- ELEC, which models electric power requirements of the overall process;
- STEAM, which models the steam system and electrical cogeneration;
- PWRBLR, which models the power boiler, coal handling, and desulfurizing area of the process;
- WATER, which models water supply and wastewater treatment; and
- SALES, which models sales revenues, material, energy, and labor costs associated with the process.

The nine subroutines are described separately in detail. Each subroutine requires a specific separate set of data input, which is provided along with sample values. A list of the mathematical calculations contained in each subroutine is also included. A flow diagram, showing the physical material and energy flows and process areas associated with each subroutine, is given whenever appropriate. Finally, a sample printout from the computer model, based on the sample input data, is provided as are user notes and guidelines for application of the model. A complete listing of the FORTRAN program is included in the Appendix.

Model Subroutines

Subroutine STPREP: Stock preparation, paper machine, finishing, and shipping area

This subroutine calculates the quantities of various inputs required in the stock preparation, paper machine, finishing, and shipping area of the overall process. It also reads prices of various inputs to that area. The data required for this subroutine include total finished paper or paperboard product output (in dry tons per day), rates of use of chemicals and sizing additives in stock preparation, moisture content of sheet into and out of the paper machine dryer, and so on. Altogether, 26 items of data are required. The specific parameters, each assigned a four-letter code name, are listed in alphabetical order:

- ACID -Quantity of concentrated sulfuric acid added to system in stock preparation (pounds/dry ton of paper or paperboard produced).
- ALUM -Quantity of alum added in stock preparation as dry alum solids in liquid slurry (pounds/dry ton of paper or paperboard produced).
- DBKT -Paper or paperboard recycled as dry "broke" and trim to stock preparation (ratio of total paper or paperboard production).
- DFOM -Quantity of defoamer additives in stock preparation and machine areas (pounds/dry ton of paper or paperboard produced).
- DSMC -Moisture content of sheet entering heated dryer section (ratio of total weight of sheet).
- PACD -Purchase price, f.o.b. mill, of sulfuric acid (\$/ton).
- PALM -Purchase price, f.o.b. mill, of alum (\$/ton).
- PCOR -Price of recycled old corrugated, used as raw material furnish in stock preparation (\$/dry ton).
- PDFM -Purchase price, f.o.b. mill, of defoamer (\$/ton).
- PMND -Minimum density of paper or paperboard product (dry pounds/1,000 feet³).
- PPAP -Price of other recycled paper used as raw material in stock preparation (\$/dry ton).
- PPDN -Average density of paper or paperboard product (dry pounds/1,000 feet³).
- PPMC -Average reel moisture content of paper or paperboard product (total weight basis).
- PPRD -Paper or paperboard production volume of the mill (dry tons/day).
- PRSN -Purchase price, f.o.b. mill, of rosin (\$/ton).
- PSLM -Purchase price, f.o.b. mill, of silicide (\$/ton).
- PSTC -Purchase price, f.o.b. mill, of starch (\$/ton).
- RCOR -Recycled old corrugated raw material as a ratio of total weight of paper (board) product (decimal ratio of dry product weight). Recycled furnish enters in stockprep.
- RCYD -Yield or recovery weight for recycled old corrugated (ratio of raw material dry weight recovered in product).
- RPAP -Recycled paper raw material as a ratio of total weight of paper (board) product (decimal ratio of dry product weight).

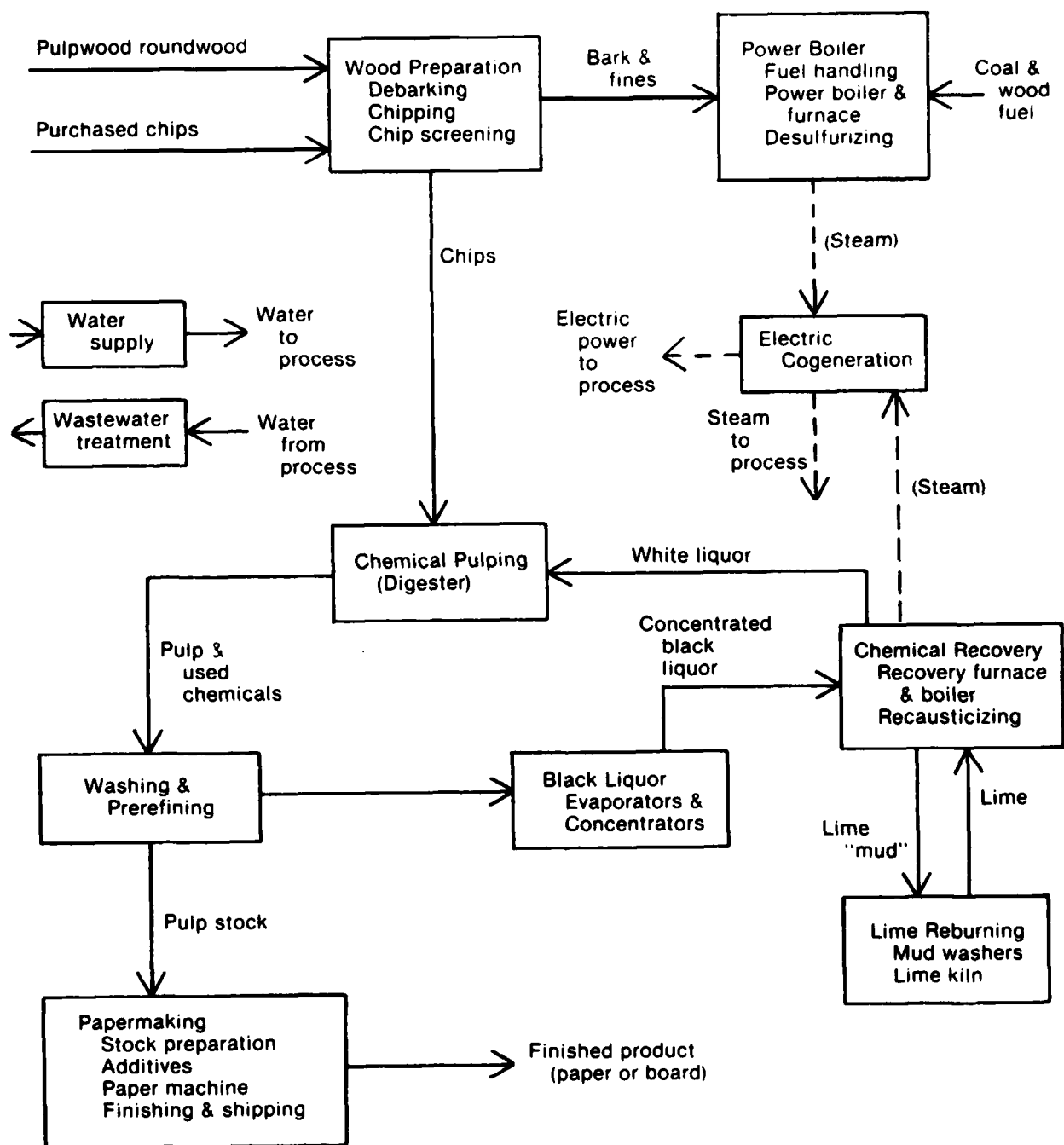


Figure 1.—Schematic of an unbleached kraft papermaking process.

- RPYD -Yield or recovery rate for recycled paper raw material (ratio of raw material dry weight recovered in product).
- ROSN -Quantity of rosin added in stock preparation as rosin solids (pounds/dry ton of paper or paperboard produced).
- SLIM -Quantity of slimicide additives (pounds/dry ton of product).
- STRC -Quantity of starch additives in stock preparation as dry solids (pounds/dry ton of paperboard product).
- SVAL -Average sales value, f.o.b. mill, of paper or paperboard product (\$/dry ton).
- TRWD -Trimmed reel width on sheet roll winder (inches).

Calculations in Subroutine STPREP are:

Calculate total dry weight of chemical and sizing additives, assuming all of alum, starch, and rosin additives are in final product, plus one-half of acid, defoamer, and slimicide additives, by weight (pounds/dry ton of product).

$$ADTV = ALUM + STRC + ROSN + 0.5 \times (ACID + DFOM + SLIM)$$

Calculate quantity of recycled old corrugated used (dry tons/day):

$$RCRT = RCOR \times ((PPRD - (PPRD \times ADTV/2000.0))/RCYD)$$

Calculate quantity of recycled paper used (dry tons/day):

$$RPPT = RPAP \times ((PPRD - (PPRD \times ADTV/2000.0))/RPYD)$$

Calculate wood pulp production quantity required (dry tons of pulp/day):

$$PROD = PPRD - (PPRD \times ADTV/2000.0) - (RCRT \times RCYD) - (RPPT \times RPYD)$$

Calculate total dry paper throughput of paper machine, including product plus dry broke and dry trims volume recycled (dry tons/day):

$$TDPT = PPRD + (PPRD \times DBKT)$$

Calculate average operational paper machine speed (lineal feet of finished paper sheet/min):

$$ASPD = ((PPRD/1440.0) \times (2000.0)/(PPDN/1000.0))/(TRWD/12.0)$$

Calculate maximum operational paper machine speed (lineal feet of finished product /min):

$$MSPD = ((PPRD/1440.0) \times (2000.0)/(PMND/1000.0))/(TRWD/12.0)$$

Calculate total water removal in heated dryer section of paper machine (tons/day):

$$TWRD = (TDPT/(1.0 - DSMC)) - (TDPT/(1.0 - PPMC))$$

Calculate each additive required (tons/day):

$$TALM = PPRD \times ALUM/2000.0$$

$$TACD = PPRD \times ACID/2000.0$$

$$TSTC = PPRD \times STRC/2000.0$$

$$TDFM = PPRD \times DFOM/2000.0$$

$$TRSN = PPRD \times ROSN/2000.0$$

$$TSLM = PPRD \times SLIM/2000.0$$

A flow diagram (fig. 2) illustrates the process areas and parameters modeled in this subroutine. The data parameters are underlined and parameters calculated (see list of calculations) in this subroutine are shown in parentheses. Note that figure 2 includes parameters related to steam demands and electric power factors used in later subroutines.

Subroutine DIG: Digester, pulp washers, black liquor evaporators, and concentrators area

This subroutine calculates the quantities of inputs and outputs in the digester(s), pulp washers, black liquor evaporators, and concentrators area. Results are based in part on the quantity of wood pulp required in stock preparation, as derived by the previous subroutine. Fourteen additional items of data are required for this subroutine:

- AACN -Active alkali concentration in white liquor (pounds/cubic foot white liquor).
- AALK -Active alkali (in white liquor entering digester), sodium hydroxide and sodium sulfide in white liquor, in sodium oxide weight equivalent (decimal ratio of dry wood weight).
- BSDS -Black liquor solids in weak black liquor from digester and washers to evaporators (tons of dry solids/dry ton of pulp).
- CCBL -Solids content of concentrated black liquor, exiting concentrators to salt cake mix tank in recovery boiler area (liquor solids weight ratio of total liquor).
- CEBL -Solids content of evaporated black liquor, exiting evaporators and entering concentrators (liquor solids weight ratio of total liquor).
- CNBL -Solids content of weak black liquor exiting washers to evaporators (black liquor solids weight ratio of total black liquor weight).
- PWMC -Pulpwood moisture content entering chip feed (decimal ratio of wet weight).
- PYLD -Pulp yield, oven-dry weight of pulp to dry weight of pulp chip raw material entering digester (decimal ratio).
- SCLS -Total salt cake (sodium sulfate) losses, or "make-up chemical" requirements (salt cake added in recovery) (pounds/dry ton of pulp).
- SCPL -Salt cake loss in pulp out of washers (ratio of total salt cake losses). (Remaining salt cake losses are assumed to occur in evaporators, recovery furnace, and recausticizing areas.)

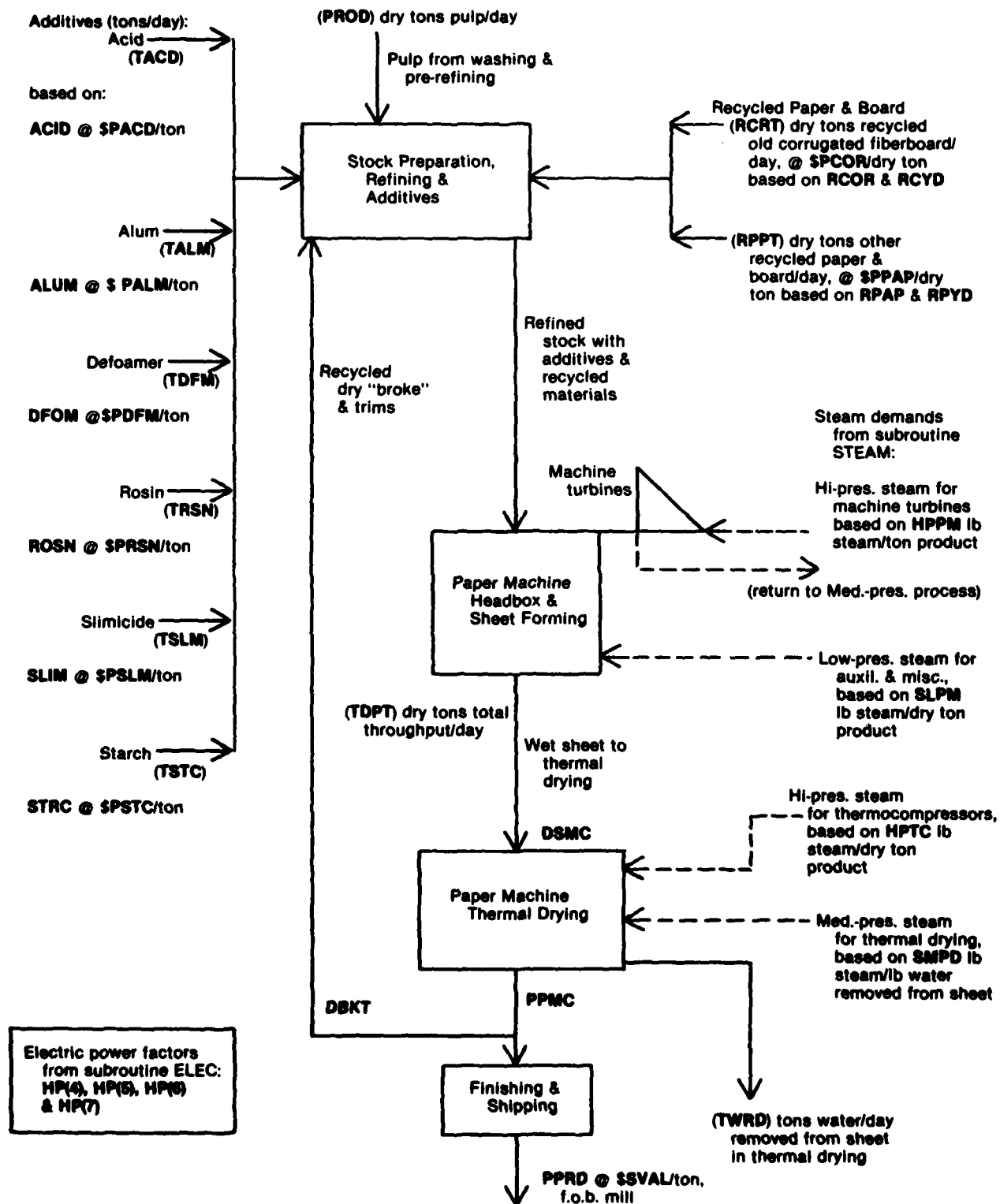


Figure 2.—Stock preparation, paper machine, finishing and shipping area: Subroutine STPREP.

SOAP -Quantity of saponified fatty acids (soap) recovered in soap skimmer in evaporator area (soap will go to external tall oil plant) (dry pounds/ton of wood chips into digester).
 SOPP -Sales value, f.o.b. mill, of soap skimmings (\$/ton).
 TPSV -Turpentine sales value, f.o.b. mill (\$/gallon).
 TURP -Turpentine recovery (gallons/ton of wood chips into digester).

Calculations for Subroutine DIG are:

Calculate quantity of pulpwood chips required as input to digester (dry tons/day):

$$PPWD = PROD/PYLD$$

Calculate turpentine recovery from wood chips:

(A) Calculate recovery (gallons/day):

$$TRPD = TURP \times PPWD$$

(B) Turpentine specific gravity:

$$TSPG = 0.6$$

(C) Turpentine recovery (tons/day):

$$TRTD = TRPD \times (0.13368) \times (62.4) \times TSPG/2000.0$$

Calculate black liquor solids to evaporators in weak black liquor (tons/day):

$$TBLS = PROD \times BSLS$$

Calculate water to evaporators in weak black liquor (tons/day):

$$WBLW = (TBLS/CNBL) - TBLS$$

Calculate soap recovery and black liquor solids remaining after soap recovery (tons/day):

$$SOPR = SOAP \times PPWD/2000.0$$

$$TBLS = TBLS - SOPR$$

Calculate active alkali required in sodium oxide weight equivalent (in white liquor to digester) (tons/day):

$$TDAA = AALK \times PPWD$$

Calculate wet weight of pulpwood chips into digester (tons/day):

$$PWIN = PPWD(1.0 - PWMC)$$

Calculate water in evaporated liquor to black liquor concentrators (tons/day):

$$EBLW = (TBLS/CEBL) - TBLS$$

Calculate water removal in evaporators (tons/day):

$$WREV = WBLW - EBLW$$

Calculate water in concentrated black liquor to recovery area (tons/day):

$$CBLW = (TBLS/CCBL) - TBLS$$

Calculate water removal in black liquor concentrators (tons/day):

$$WRCN = EBLW - CBLW$$

Calculate white liquor volume to digester (thousand gallons/day):

$$TWLV = ((TDAA \times 2000.0)/AACN)/133.68056$$

A flow diagram (fig. 3) shows the process area and parameters modeled in this subroutine. Parameters calculated in this subroutine are in parentheses. Note also that figure 3 includes parameters related to steam demands and electric power factors used in later subroutines.

Subroutine WDPREP: Wood preparation area

This subroutine calculates the quantities of various kinds of pulpwood required as input to the wood preparation area. Six kinds of pulpwood are included in the model: hardwood species-roundwood, purchased whole-tree chips and purchased "clean" chips; and softwood species-roundwood, purchased whole-tree chips and purchased "clean" chips. This subroutine also calculates the quantities of wood "residues," bark and fines, generated in the wood preparation area. A total of 27 items of data is required by this subroutine:

HBPC -Weight ratio removed as bark in debarking hardwood roundwood pulpwood (ratio of total dry weight of purchased roundwood including bark).
 HCHM -Moisture content of hardwood purchased "clean" chip pulpwood (decimal ratio of wet weight, average).
 HTCF -Fines removed in screening hardwood purchased "clean" chips (ratio of total dry weight of chips).
 HWCD -Total weight per cord of hardwood roundwood pulpwood, wet weight basis (pounds/cord including bark, as purchased).
 HWFR -Fines removed in screening hardwood roundwood chips (ratio of total dry weight of hardwood roundwood chips before screening).
 HWMC -Average moisture content in hardwood roundwood pulpwood (ratio of total wet weight of pulpwood as purchased, including bark).
 HWPC -Hardwood purchased chip furnish (whole-tree and "clean") as a ratio of total hardwood into digester (fraction of total dry weight of hardwood purchased chip and roundwood furnish).

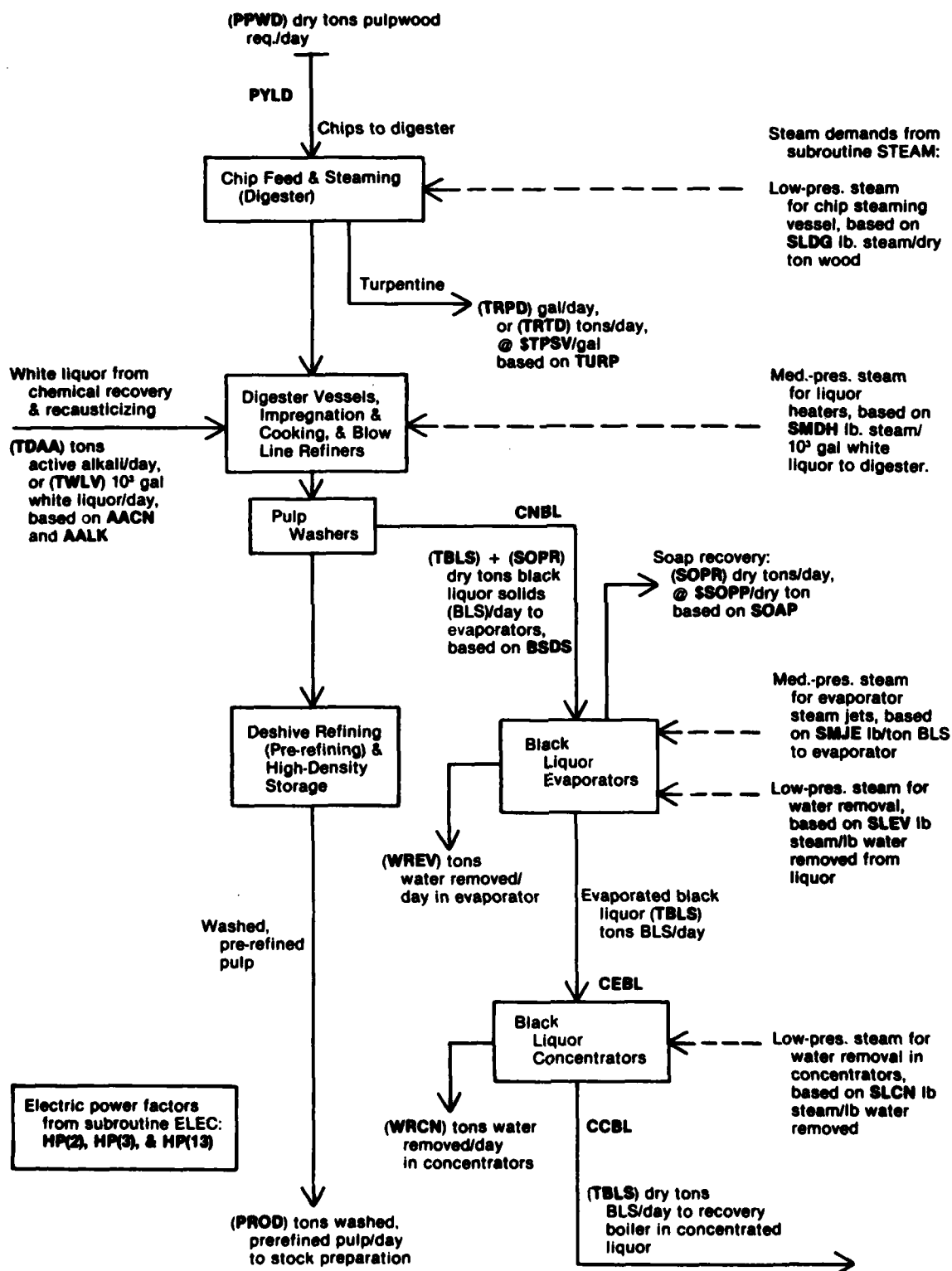


Figure 3.—Digester, pulp washing, pre-refining and evaporator area: Subroutine DIG.

HWTC - Hardwood whole-tree chips as a ratio of total hardwood purchased chips (ratio of total dry weight of hardwood purchased chips).
HWTF - Bark and fines removed in screening hardwood whole-tree chips (decimal ratio of total dry weight of hardwood whole-tree chips).
HWTM - Moisture content of hardwood purchased whole-tree chips (decimal ratio of wet weight, average).
PHPC - Price or value of hardwood purchased "clean" chips (\$/ton as purchased, average).
PHRW - Purchase price, f.o.b. mill, of hardwood roundwood (\$/cord, average).
PHWC - Purchase price, f.o.b. mill, of hardwood whole-tree chips (\$/ton as purchased, average).
PSPC - Price or value of softwood purchased "clean" chips (\$/ton as purchased, average).
PSRW - Purchase price, f.o.b. mill, of softwood roundwood (\$/cord, average).
PSWC - Purchase price, f.o.b. mill, of softwood whole-tree chips (\$/ton as purchased, average).
SBPC - Weight ratio removed as bark in debarking softwood roundwood pulpwood (ratio of total dry weight of purchased roundwood, including bark).
SCHM - Moisture content of softwood purchased "clean" chip pulpwood (decimal ratio of wet weight, average).
SFWD - Softwood ratio of total pulpwood furnish into digester (decimal ratio of total dry weight of furnish).
STCF - Fines removed in screening softwood purchased "clean" chips (ratio of total dry weight of softwood purchased "clean" chips).
SWCD - Total weight per cord of softwood roundwood pulpwood, wet weight basis (pounds/cord including bark, as purchased).
SWFR - Fines removed in screening softwood roundwood chips (ratio of total dry weight of softwood roundwood chips before screening).
SWMC - Average moisture content in softwood roundwood pulpwood (ratio of total wet weight of pulpwood as purchased, including bark).
SWPC - Softwood purchased chip furnish (whole-tree and "clean") as a ratio of total softwood into digester (fraction of total dry weight of softwood purchased chip and roundwood furnish).
SWTC - Softwood whole-tree chips as a ratio of total softwood purchased chips (ratio of total dry weight of softwood purchased chips).
SWTF - Bark and fines removed in screening softwood whole-tree chips (decimal ratio of total dry weight of softwood whole-tree chips).
SWTM - Moisture content of softwood purchased whole-tree chips (decimal ratio of wet weight, average).

Calculations for Subroutine WDPREP are:

Calculate quantity of softwood chips into digester (dry tons/day):

$$SPWD = PPWD \times SFWD$$

Calculate quantity of hardwood chips into digester (dry tons/day):

$$HPWD = PPWD \times (1.0 - SFWD)$$

Calculate quantity of softwood roundwood chips into digester (dry tons/day):

$$SRPW = SPWD \times (1.0 - SWPC)$$

Calculate quantity of hardwood roundwood chips into digester (dry tons/day):

$$HRPW = HPWD \times (1.0 - HWPC)$$

Calculate quantity of softwood fines removed in screening softwood roundwood pulpwood chips (fines go to power boiler) (dry tons/day):

$$SRFR = (SRPW / (1.0 - SWFR)) \times SWFR$$

Calculate quantity of hardwood fines removed in screening hardwood roundwood pulpwood chips (fines go to power boiler) (dry tons/day):

$$HRFR = (HRPW / (1.0 - HWFR)) \times HWFR$$

Calculate quantity of softwood bark removed from softwood roundwood (to power boiler) (dry tons/day):

$$SBRK = ((SRPW + SRFR) / (1.0 - SBPC)) \times SBPC$$

Calculate quantity of hardwood bark removed from hardwood roundwood (to power boiler) (dry tons/day):

$$HBRK = ((HRPW + HRFR) / (1.0 - HBPC)) \times HBPC$$

Calculate required quantity of softwood roundwood pulpwood (cords/day):

$$CDSW = ((SRPW + SRFR + SBRK) / (1.0 - SWMC)) / (SWCD / 2000.0)$$

Calculate required quantity of hardwood roundwood pulpwood (cords/day):

$$CDHW = ((HRPW + HRFR + HBRK) / (1.0 - HWMC)) / (HWCD / 2000.0)$$

Calculate quantity of screened softwood purchased chips into digester (dry tons/day):

$$SPCH = SPWD \times SWPC$$

Calculate quantity of screened hardwood purchased chips into digester (dry tons/day):

$$HPCH = HPWD \times HWPC$$

Calculate quantity of softwood fines, including fines from whole-tree chips and "clean" chips screening (fines to power boiler) (dry tons/day):

$$\text{SWCF} = ((\text{SPCH} \times \text{SWTC}) / (1.0 - \text{SWTF})) \times \text{SWTF}$$

$$\text{SPCF} = ((\text{SPCH} \times (1.0 - \text{SWTC})) / (1.0 - \text{STCF})) \times \text{STCF}$$

Calculate quantity of hardwood fines, including fines from whole-tree chip and "clean" chip screening (fines to power boiler) (dry tons/day):

$$\text{HWCF} = ((\text{HPCH} \times \text{HWTC}) / (1.0 - \text{HWTF})) \times \text{HWTF}$$

$$\text{HPCF} = ((\text{HPCH} \times (1.0 - \text{HWTC})) / (1.0 - \text{HTCF})) \times \text{HTCF}$$

Calculate quantity of "clean" softwood chips including fines (dry tons/day):

$$\text{SPCC} = (\text{SPCH} \times (1.0 - \text{SWTC})) + \text{SPCF}$$

Calculate quantity of softwood whole-tree chips including fines (dry tons/day):

$$\text{SPWC} = (\text{SPCH} \times \text{SWTC}) + \text{SWCF}$$

Calculate quantity of "clean" hardwood chips including fines (dry tons/day):

$$\text{HPCC} = (\text{HPCH} \times (1.0 - \text{HWTC})) + \text{HPCF}$$

Calculate quantity of hardwood whole-tree chips including fines (dry tons/day):

$$\text{HPWC} = (\text{HPCH} \times \text{HWTC}) + \text{HWCF}$$

Calculate quantity of "clean" softwood chips as received (tons/day) (wet weight basis):

$$\text{SCCW} = \text{SPCC} / (1.0 - \text{SCHM})$$

Calculate quantity of softwood whole-tree chips as received (tons/day) (wet weight basis):

$$\text{SWCW} = \text{SPWC} / (1.0 - \text{SWTM})$$

Calculate quantity of "clean" hardwood chips as received (tons/day) (wet weight basis):

$$\text{HCCW} = \text{HPCC} / (1.0 - \text{HCHM})$$

Calculate quantity of hardwood whole-tree chips as received (tons/day) (wet weight basis):

$$\text{HWCW} = \text{HPWC} / (1.0 - \text{HWTM})$$

A flow diagram (fig. 4) illustrates the process area modeled in this subroutine. Parameters calculated in this subroutine are shown in parentheses. Note also that the results obtained in this subroutine will be based in part on the quantity of pulpwood required in the digester, as calculated in subroutine DIG.

Subroutine RECBLR: Recovery boiler, lime kiln, and recausticizing area

This subroutine calculates the quantity of steam heat energy generated in the recovery boiler, with concentrated black liquor as fuel, and calculates the quantities of various other inputs required in the chemical recovery, recausticizing, and lime system area. A total of 16 items of data is required for this subroutine:

- ACTV** - Activity of white liquor (ratio of active alkali to total alkali, in sodium oxide weight equivalents).
- AVLM** - Lime availability (active calcium oxide weight ratio of total lime to slaker) (Remainder is assumed to be inert material in causticizing reaction.)
- CAUS** - Causticizing efficiency of causticizing reaction (measured as the weight ratio of sodium hydroxide to sodium hydroxide plus sodium carbonate in white liquor, expressed in sodium oxide weight equivalents, and in which the sodium hydroxide content of green liquor has been subtracted from the white liquor content (standard TAPPI definition)).
- CNMD** - Consistency of the filtered lime mud entering the lime kiln (dry weight of lime mud solids ratio of total weight of filtered lime mud).
- EKFF** - Average combustion heating efficiency of kiln fuel (ratio of higher heating value of fuel which is not lost in combustion gases and excess air exiting the kiln).
- FLMR** - Weight fraction of total lime mud recycled to the mud washer, representing uncalcined material captured in the lime kiln flue gas scrubber and emissions separator.
- HHKF** - Average higher heating value of kiln fuel (million Btu/fuel unit).
- HRRB** - Effective heat recovery ratio of recovery boiler (decimal ratio of gross heat energy value of black liquor solids recovered as steam heat energy (adjusted for total heat inputs to furnace and heat of reaction correction, as well as for combustion heat losses). (Not to be confused with combustion heat recovery efficiency of recovery boiler.))
- HVBL** - Gross heat energy value (higher heating value) of black liquor solids (Btu/dry pound).
- PLMU** - Purchased lime make-up (average weight ratio of total lime to slaker which is purchased or "make-up" lime).
- PPKF** - Average purchase price of kiln fuel (\$/fuel unit).
- PPLM** - Purchase price, f.o.b. mill, of purchased lime (\$/ton).
- SVSC** - Sales value, f.o.b. mill, of surplus salt cake generated in chemical recovery and desulfurization areas (\$/dry ton of surplus saltcake).

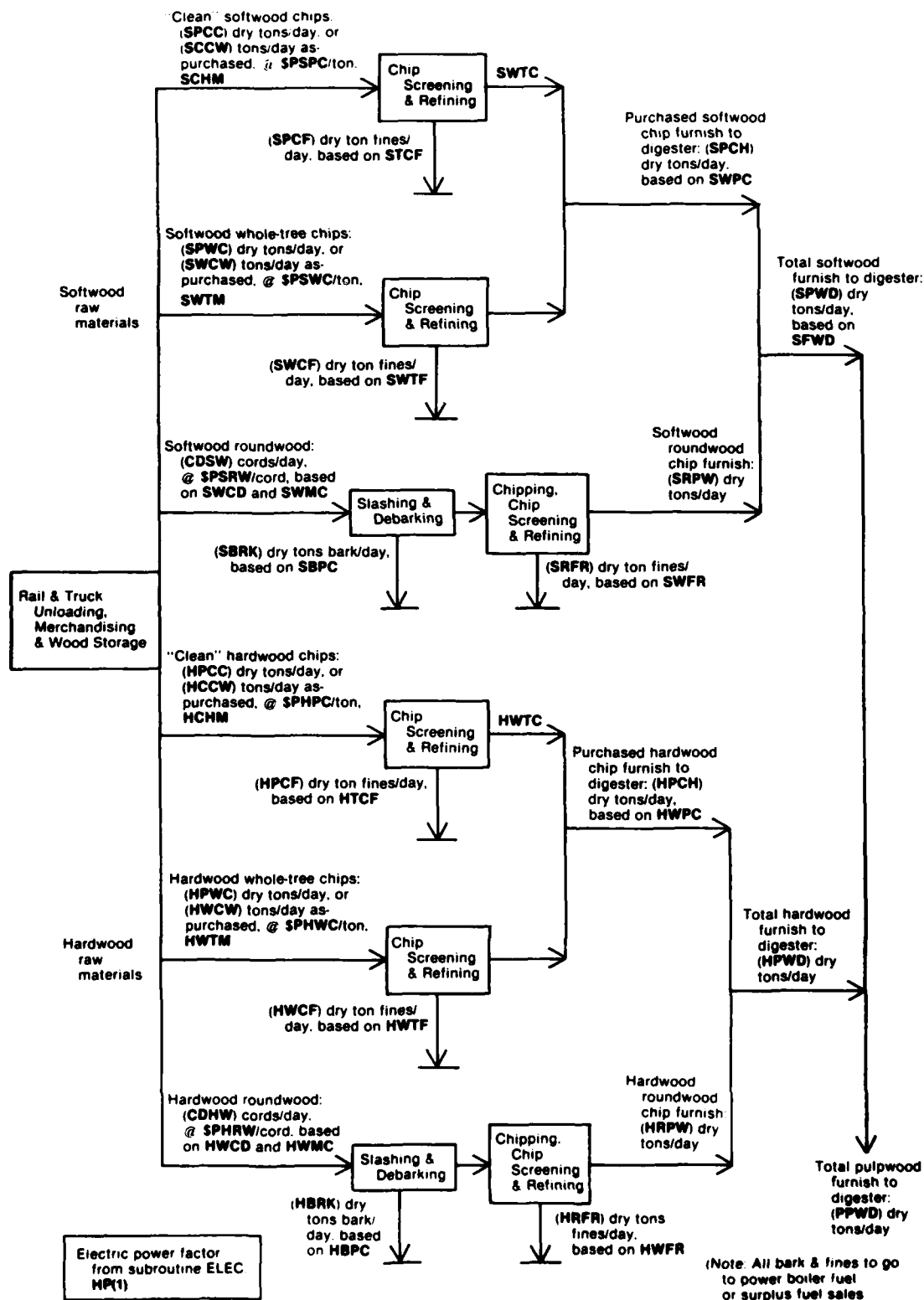


Figure 4.—Wood preparation area: Subroutine WDPREP.

SSWL - Sodium sulfate ratio of total alkali in white liquor (one-half weight ratio in sodium oxide equivalents).
 TKEG - Temperature of kiln exit gases ($^{\circ}\text{F}$, average).
 TKPD - Average temperature of kiln product solids exiting kiln ($^{\circ}\text{F}$).

Calculations for Subroutine RECBLR are:

Calculate heat energy to steam in recovery boiler (million Btu/day):

$$\text{HSRB} = \text{TBSL} \times (0.002) \times \text{HVBL} \times \text{HRRB}$$

Calculate weight equivalent of total alkali (total sodium compounds) in white liquor, in sodium oxide weight equivalent (tons/day):

$$\text{TALK} = \text{TDAA}/\text{ACTV}$$

Calculate weight equivalent of sodium sulfate in white liquor, in sodium oxide weight equivalent (tons/day):

$$\text{SDSL} = \text{TALK} \times \text{SSWL}$$

Calculate weight equivalent of sodium carbonate in white liquor, in sodium oxide weight equivalent (tons/day):

$$\text{SDCA} = \text{TALK} - (\text{TDAA} + \text{SDSL})$$

Calculate weight equivalent of sodium hydroxide produced in causticizing reaction, in sodium oxide weight equivalent, corrected for sodium hydroxide present in green liquor, based on TAPPI definition of causticizing efficiency (tons/day):

$$\text{SODH} = (\text{CAUS} \times \text{SDCA}) / (1.0 - \text{CAUS})$$

Calculate actual weight of calcium oxide needed in causticizing reaction (tons/day):

$$\text{CAOX} = \text{SODH} \times (56.0/62.0)$$

Calculate quantity of purchased lime required (tons/day):

$$\text{PLRQ} = (\text{CAOX} \times \text{PLMU}) / (\text{AVLM})$$

Calculate total weight of lime produced in lime kiln to slaker (tons/day):

$$\text{TWLP} = (\text{CAOX}/\text{AVLM}) - \text{PLRQ}$$

Calculate weight of inert material in lime from lime kiln to slaker (tons/day):

$$\text{WINR} = \text{TWLP} \times (1.0 - \text{AVLM})$$

Calculate theoretical dry weight of lime mud to lime kiln (tons/day):

$$\text{WTLM} = ((\text{TWLP} - \text{WINR}) \times (100.0/56.0)) + \text{WINR}$$

Calculate actual dry weight of lime mud to lime kiln after correcting for particulate emissions and recycled fraction (to mud washer) (tons/day):

$$\text{WTLM} = \text{WTLM} / (1.0 - \text{FLMR})$$

Calculate weight of water entering lime kiln with filtered lime mud (tons/day):

$$\text{WIMK} = (\text{WTLM}/\text{CNMD}) \times (1.0 - \text{CNMD})$$

Calculate heat energy requirements for lime kiln (million Btu/day) (assuming ambient temperature of 70°F):

(A) Energy required to evaporate water in lime mud entering kiln:

$$\text{WTEN} = \text{WIMK} \times (0.002) \times (970.0 + (212.0 - 70.0) + (0.46 \times (\text{TKEG} - 212.0)))$$

(B) Energy into kiln product, assuming a specific heat of 0.25 Btu/pound of kiln product/ $^{\circ}\text{F}$ above ambient temperature:

$$\text{PLEN} = \text{TWLP} \times (0.002) \times (\text{TKPD} - 70.0) \times 0.25$$

(C) Energy required for dissociation of calcium carbonate in lime kiln, assuming a heat of dissociation of 1,390 Btu/pound of active calcium oxide in lime kiln product:

$$\text{HDEN} = (\text{TWLP} \times \text{AVLM}) \times (0.002) \times (1390.0)$$

(D) Energy into carbon dioxide produced in dissociation reaction, assuming a specific heat of 0.25 Btu/pound of carbon dioxide gas/ $^{\circ}\text{F}$ above ambient temperature:

$$\text{CDEN} = (\text{TWLP} \times \text{AVLM}) \times (44.0/56.0) \times (0.002) \times (0.25) \times (\text{TKEG} - 70.0)$$

(E) Calculate energy into recycled lime mud (e.g. flue gas dust) captured in scrubber and separators, assuming a specific heat of 0.25 Btu/pound of "dust"/ $^{\circ}\text{F}$ above ambient:

$$\text{EMEN} = (\text{WTLM} \times \text{FLMR}) \times (0.002) \times (\text{TKEG} - 70.0) \times 0.25$$

(F) Calculate total heat energy requirements including a 15.0% factor for thermal radiation heat losses:

$$\text{THEN} = (\text{WTEN} + \text{PLEN} + \text{HDEN} + \text{CDEN} + \text{EMEN}) \times 1.15$$

Calculate gross energy input requirements in kiln fuel (million Btu/day):

$$\text{GHEN} = \text{THEN}/\text{EFKF}$$

Calculate kiln fuel required (units/day):

$$\text{TKFR} = \text{GHEN}/\text{HHKF}$$

A flow diagram (fig. 5) shows the process area modeled in this subroutine. Parameters calculated in this subroutine are in parentheses. Note that figure 5 includes parameters related to steam demands and electric power factors used in later subroutines. Note also that the results of this subroutine depend on the quantity of black liquor solids, as calculated in subroutine DIG.

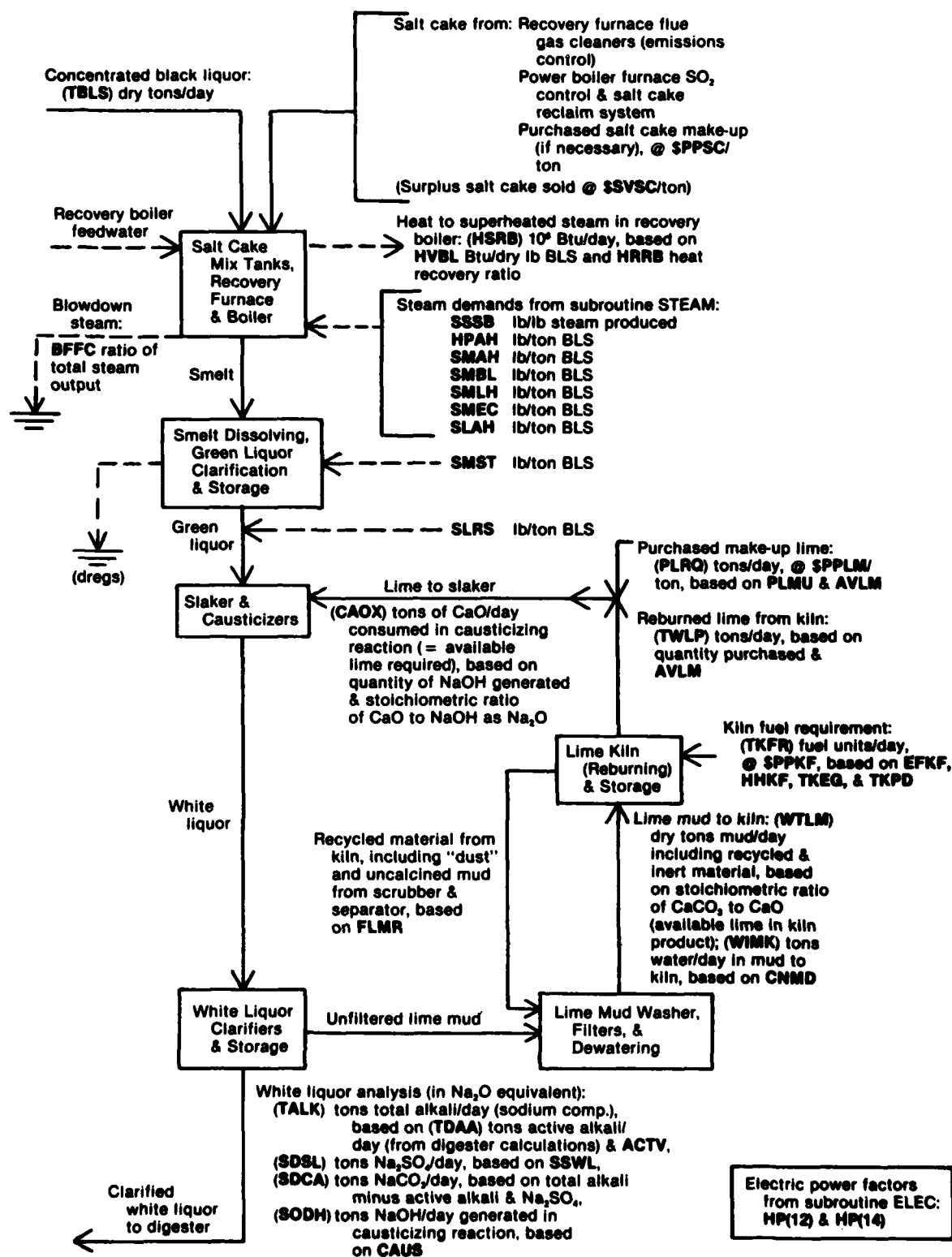


Figure 5.—Chemical recovery, lime kiln and recausticizing area: Subroutine RECBLR.

Subroutine ELEC: Electric power requirements

This subroutine calculates total electric power requirements of the overall process. A total of 19 items of data is required:

(Total connected horsepower of machines and equipment by mill area):

- HP (1) - Wood preparation
- HP (2) - Digester and turpentine area
- HP (3) - Washing and refining
- HP (4) - Stock preparation
- HP (5) - Paper machine area
- HP (6) - Additives area
- HP (7) - Finishing and shipping
- HP (8) - Water supply and treatment
- HP (9) - Waste disposal
- HP (10) - Power boiler, feedwater, and condensate areas
- HP (11) - Coal handling
- HP (12) - Recovery boiler area
- HP (13) - Evaporators area
- HP (14) - Lime kiln and recausticizing
- HP (15) - Air supply system
- HP (16) - Odor collection system

AEFU - Average efficiency of electrical energy use in mill equipment (decimal ratio of electric energy demand).

ALFC - Average power load factor for mill equipment (decimal ratio of total connected horsepower).

ANML - Average nonmotor load for mill and related facilities, for lighting and miscellaneous (kilowatts).

Calculations for Subroutine ELEC are:

Calculate total connected horsepower of mill machines and equipment:

$$TCHP = 0.0$$

$$TCHP = TCHP + HP(I), \text{ for } I = 1 \text{ to } 16$$

Calculate power load of mill machines and equipment (total horsepower):

$$TPLD = TCHP \times ALFC$$

Calculate total electrical power demand of mill machines and equipment (kilowatts):

$$TEED = (TPLD/AEFU) \times 0.746$$

Calculate total electrical power demand of mill, including nonmotor load:

$$TEED = TEED + ANML$$

Note that the electric power factors are used in each of the process subroutines (see flow diagrams).

Subroutine STEAM: Steam system, electric power, and cogeneration area

The purpose of this subroutine is to calculate the total process steam demands, to balance steam demands with steam output from the recovery and power boilers, to determine the quantity of cogenerated electric power, and to estimate the quantities of other related inputs and outputs for the steam system, electric power, and cogeneration areas of the process.

The model assumes three levels of process steam: high, medium, and low pressure. The model also assumes all process steam is obtained via a cogenerating turbine, which in turn obtains higher-pressure superheated steam from the power and recovery boilers. The assumptions built into this subroutine reflect typical conventional process design.

A total of 46 items of data is required for this subroutine. They include steam loss ratios, heat exchange efficiency, enthalpies of steam, feedwater, and make-up water, ratios of steam recovered, turbine generator efficiency, and various specific rates of process steam demand throughout the entire process:

BFFC - Blowdown ratio for power and recovery boilers (pounds blown/total pounds of steam produced in boilers). (Blow to flash tanks assumed to have low enthalpy and may be used to heat feedwater, but heat content is not accounted for here.)

CNSL - Losses from steam system in condensate receiver and deaerator (pounds of steam or condensate lost (e.g., in vents, etc.)/pound of total feedwater to power and recovery boilers).

FWHE - Feedwater heater heat exchange efficiency (ratio of heat input that exits in feedwater, average).

HCCN - Enthalpy of combined condensate from steam system to deaerator (Btu/pound of condensate).

HCMW - Enthalpy of make-up water to deaerator (Btu/pound of make-up water).

HHPP - Enthalpy of high-pressure process steam (Btu/pound of steam).

HLPP - Enthalpy of low-pressure process steam (Btu/pound of steam).

HMPP - Enthalpy of medium-pressure process steam (Btu/pound of steam).

HSHP - Enthalpy of superheated steam from boilers (Btu/pound of steam).

HTMS - Ratio of total high-pressure process steam recovered as medium-pressure process steam, excluding steam from turbines (ratio of total high-pressure steam).

- PKWH - Price of purchased electrical energy (\$/kilowatt-hour).
- SMLS - Ratio of total medium-pressure process steam recovered as low pressure process steam, excluding steam from turbines (ratio of total medium-pressure steam).
- SSSB - Superheated steam required for sootblowers in power and recovery boiler areas (pounds/total pounds of steam produced).
- SVSE - Sales value of surplus electrical energy cogenerated in mill (\$/kilowatt-hour).
- TGEF - Turbine generator efficiency for conversion of steam energy to electrical energy (ratio of steam energy consumed to electric energy produced).

Average high-pressure process steam demands are:

- HPAH - High-pressure steam for air heater in recovery boiler area (pounds/ton of black liquor solids to recovery boiler).
- HPFW - High-pressure steam demand for power boiler feedwater heaters (pounds/pound of feedwater to power boiler).
- HPMD - High-pressure steam miscellaneous demand volume (pounds/ton of product).
- HPPB - High-pressure steam demand for power boiler area, air heaters, and miscellaneous (pounds/pound of steam produced in power boiler).
- HPPM - High-pressure steam demand of paper machine and vacuum pump turbines (pounds/dry ton of paper or paperboard product). (This steam discharges to medium-pressure process steam header.)
- HPSL - Losses from high-pressure process steam system (ratio of total high-pressure process steam not returned in condensate).
- HPTC - High-pressure steam demand of paper machine thermocompressors for dryer drainage (pounds/dry ton of paper or paperboard product).

Average medium-pressure process steam demands are:

- SMAH - Medium-pressure steam demand for air heater in recovery boiler area (pounds/ton of black liquor solids to recovery boiler).
- SMAS - Medium-pressure steam demand for air supply area (pounds/dry ton of pulp produced).
- SMBL - Medium-pressure steam demand for black liquor guns in recovery boiler furnace (pounds/ton of black liquor solids to recovery furnace).
- SMDH - Medium-pressure steam demand for digester liquor heater (pounds/thousand gallons of white liquor to digester).
- SMFW - Medium-pressure steam demand for power boiler feedwater heaters (pounds/pound of feedwater to power boiler).

- SMEC - Medium-pressure steam demand for emissions control (electrostatic precipitators) in recovery boiler area (pounds/ton of black liquor solids to recovery furnace).
- SMJE - Medium-pressure steam for steam jets in evaporators (pounds/ton of black liquor solids into evaporators).
- SMLH - Medium-pressure steam demand for secondary black liquor heater in recovery boiler area (pounds/ton of black liquor solids to recovery boiler).
- SMMD - Medium-pressure process steam miscellaneous demand volume (pounds/ton of product).
- SMPB - Medium-pressure steam demand for power boiler area, air heaters, emissions control, and miscellaneous (pounds/pound of steam produced in power boiler).
- SMPD - Medium-pressure steam demand for paper machine dryers (pounds/pound of water removed in heated dryer section of paper machine).
- SMSL - Losses from medium-pressure process steam system (ratio of total medium-pressure steam not returned in condensate).
- SMST - Medium-pressure steam demand for smelt dissolving tank in recovery area (pounds/ton of black liquor solids to recovery boiler).

Average low-pressure process steam demands are:

- SLAH - Low-pressure steam demand for air heater in recovery boiler area (pounds/ton of black liquor solids to recovery).
- SLCN - Low-pressure steam demand for black liquor concentrators (pounds/pound of water removed in black liquor concentrators).
- SLDA - Low-pressure steam demand for deaerator (pounds/pound of total feedwater).
- SLDG - Low-pressure steam demand for digester steaming vessel (pounds/dry ton of chips to digester).
- SLEV - Low-pressure steam demand for black liquor evaporators (pounds/pound of water removed from black liquor in evaporators).
- SLMD - Low-pressure miscellaneous steam demand (pounds/dry ton of paper or paperboard product).
- SLPB - Low-pressure steam demand for power boiler area, air heaters, emissions control, etc. (pounds/pound of steam produced in power boiler).
- SLPM - Low-pressure steam demand for paper machine auxiliary equipment and miscellaneous purposes (pounds/dry ton of product).
- SLRS - Low-pressure steam demand for heating green liquor to slaker in recausticizing area (pounds/ton of black liquor solids to recovery area).

- SLSE - Low-pressure steam demand for sulfur emissions odor control, collection system (pounds/dry ton of pulp produced).
- SLSL - Losses from low-pressure process steam system (ratio of total low-pressure steam volume not returned in condensate to deaerator).

Calculations for Subroutine STEAM are:

Set initial feedwater enthalpy to zero:

$$\text{HFWR} = 0.0$$

Calculate initial estimate of recovery boiler steam output (pounds of superheated steam/day):

$$\text{SORB} = (\text{HSRB} \times 1000000.0) / (\text{HSHP} - \text{HFWR})$$

Calculate initial estimates of net boiler steam demands (pounds of superheated steam/day):

-(High-pressure process steam demands, approx.)

$$\text{HPSD} = ((\text{HPPM} \times \text{PPRD}) + (\text{HPTC} \times \text{PPRD}) + (\text{HPAH} \times \text{TBLS}) + (\text{HPMD} \times \text{PPRD}))$$

-(Medium-pressure process steam demands, approx.)

$$\begin{aligned} \text{SMSD} = & ((\text{SMPD} \times \text{TWRD} \times 2000.0) + (\text{SMJE} \times (\text{TBLS} + \text{SOPR})) + (\text{SMDH} \times \text{TWLV}) + (\text{TBLS} \times (\text{SMEC} + \text{SMAH} + \text{SMST} + \text{SMLH} + \text{SMBL})) + (\text{SMAS} \times \text{PROD}) + (\text{SMMD} \times \text{PPRD}) - (\text{HPPM} \times \text{PPRD}) - ((\text{HPSD} - (\text{HPPM} \times \text{PPRD})) \times \text{HTMS})) \end{aligned}$$

-(Low-pressure process steam demands, approx.)

$$\begin{aligned} \text{SLSD} = & ((\text{PPRD} \times (\text{SLPM} + \text{SLMD})) + (\text{TBLS} \times (\text{SLRS} + \text{SLAH})) + (((\text{SLEV} \times \text{WREV}) + (\text{SLCN} \times \text{WRCN})) \times 2000.0) + (\text{SLDG} \times \text{PPWD}) + (\text{SLSE} \times \text{PROD}) - (\text{SMLS} \times \text{GMSD}) - \text{SMLP} \end{aligned}$$

Calculate initial estimate of power boiler steam output (pounds of superheated steam/day):

$$\begin{aligned} \text{SOPB} = & (\text{HPSD} + \text{SMSD} + \text{SLSD} - \text{SORB} + (\text{SSSB} \times \text{SORB}) + (\text{SLDA} \times \text{SORB} \times (1.0 + \text{BFFC})) / (1.0 - \text{SSSB} - ((\text{HPFW} + \text{SMFW} + \text{SLDA}) \times (1.0 + \text{BFFC})) - (\text{HPPB} + \text{SMPB} + \text{SLPB})) \end{aligned}$$

Follow iterative procedure to determine the steam energy balance (algorithm iterates until equilibrium enthalpy of feedwater to recovery boiler is obtained):

Calculate total steam and condensate losses from steam system, equivalent to make-up water requirements (pounds/day):

$$\begin{aligned} \text{TSL} = & (\text{SSSB} \times (\text{SOPB} + \text{SORB})) + (0.7 \times \text{BFFC} \times (\text{SOPB} + \text{SORB})) + (\text{HPSL} \times \text{HPSD}) + (\text{SMSL} \times \text{GMSD}) + (\text{SLSL} \times (\text{SLSD} + (\text{SMLS} \times \text{GMSD}))) + (\text{CNLSL} \times ((\text{SOPB} + \text{SORB}) \times (1.0 + \text{BFFC}))) \end{aligned}$$

Calculate quantity of condensate to deaerator (pounds/day) (PBFW is feedwater to power boiler):

$$\text{PBFW} = (\text{SOPB} \times (1.0 + \text{BFFC}))$$

$$\text{CNDA} = ((\text{SOPB} + \text{SORB}) \times (1.0 + \text{BFFC})) - \text{TSL} - ((\text{SMFW} + \text{HPFW}) \times \text{PBFW}) - (\text{SLDA} \times (\text{SOPB} + \text{SORB}) \times (1.0 + \text{BFFC}))$$

Calculate enthalpy of feedwater to recovery boiler and power boiler feedwater heaters (Btu/pound of feedwater):

$$\begin{aligned} \text{HFWT} = & ((\text{TSL} \times \text{HCMW}) + (\text{CNDA} \times \text{HCCN}) + (\text{SLDA} \times \text{HLPP} \times (\text{SOPB} + \text{SORB}) \times (1.0 + \text{BFFC})) + ((\text{HPFW} + \text{SMFW}) \times \text{HCCN} \times \text{PBFW}) - (\text{CNLSL} \times \text{HCCN} \times ((\text{SOPB} + \text{SORB}) \times (1.0 + \text{BFFC}))) / ((\text{SOPB} + \text{SORB}) \times (1.0 + \text{BFFC})) \end{aligned}$$

$$\text{HFWR} = (\text{HFWR} + \text{HFWT}) / 2.0$$

Recalculate steam output of recovery boiler (pounds/day):

$$\text{SORB} = (\text{HSRB} \times 1000000.0) / (\text{HSHP} - \text{HFWR})$$

Recalculate net high-pressure process steam demands (pounds/day):

$$\begin{aligned} \text{HPSD} = & ((\text{HPPM} \times \text{PPRD}) + (\text{HPTC} \times \text{PPRD}) + (\text{HPAH} \times \text{TBLS}) + (\text{HPMD} \times \text{PPRD}) + (\text{HPPB} \times \text{SOPB}) + (\text{HPFW} \times \text{PBFW})) \end{aligned}$$

Recalculate net medium-pressure process steam demands (pounds/day):

$$\begin{aligned} \text{SMSD} = & ((\text{SMPD} \times \text{TWRD} \times 2000.0) + (\text{SMDH} \times \text{TWLV}) + (\text{SMJE} \times (\text{TBLS} + \text{SOPR})) + (\text{SMAS} \times \text{PROD}) + (\text{TBLS} \times (\text{SMEC} + \text{SMAH} + \text{SMLH} + \text{SMST} + \text{SMBL})) + (\text{SMPB} \times \text{SOPB}) + (\text{SMFW} \times \text{PBFW}) + (\text{SMMD} \times \text{PPRD}) - (\text{HPPM} \times \text{PPRD}) - ((\text{HPSD} - (\text{HPPM} \times \text{PPRD})) \times \text{HTMS})) \end{aligned}$$

Recalculate net low-pressure process steam demands (pounds/day):

$$\begin{aligned} \text{SLSD} = & ((\text{SLPM} + \text{SLMD}) \times \text{PPRD}) + ((\text{SLRS} + \text{SLAH}) \times \text{TBLS}) + (\text{SLEV} \times \text{WREV} \times 2000.0) + (\text{SLCN} \times \text{WRCN} \times 2000.0) + (\text{SLDG} \times \text{PPWD}) + (\text{SLSE} \times \text{PROD}) + (\text{SLPB} \times \text{SOPB}) + (\text{SLDA} \times (\text{SOPB} + \text{SORB}) \times (1.0 + \text{BFFC})) - (\text{SMLS} \times \text{GMSD}) - \text{SMLP} \end{aligned}$$

Recalculate steam output of power boiler (pounds/day):

$$\text{SOPB} = (\text{HPSD} + \text{SMSD} + \text{SLSD} - (\text{SORB} \times (1.0 - \text{SSSB}))) / (1.0 - \text{SSSB})$$

$$\text{PPFW} = (\text{SOPB} \times (1.0 + \text{BFFC}))$$

Check feedwater enthalpy.

Reiterate to equilibrium.

Calculate the enthalpy of feedwater to power boiler, out of feedwater heaters (Btu/pound of feedwater):

$$H_{BFW} = ((P_{BFW} \times H_{FWR}) + (F_{WHE} \times (((H_{HPP} - H_{CCN}) \times H_{PFW} \times P_{BFW}) + ((H_{MPP} - H_{CCN}) \times S_{MFW} \times P_{BFW}))))/P_{BFW}$$

Calculate the steam heat energy demand on power boiler (million Btu/day) (input to power boiler subroutine):

$$S_{HDM} = ((S_{OPB} \times H_{SHP}) - (S_{OPB} \times H_{PFW}))/1000000.0$$

Calculate the amount of electrical energy cogenerated (kilowatt-hours/day) (1 kilowatt-hour = 3413.0 Btu of energy equivalent):

$$COGN = T_{GEF} \times (((H_{SHP} - H_{HPP}) \times H_{PSD}) + ((H_{SHP} - H_{MPP}) \times S_{MSD}) + ((H_{SHP} - H_{LPP}) \times S_{LSD}))/3413.0$$

Calculate purchased electrical energy requirements (kilowatt-hours/day):

$$P_{ERQ} = (T_{EED} \times 24.0) - COGN$$

$$S_{REE} = 0.0$$

Calculate surplus electrical energy, if any, produced and sold (kilowatt-hours/day):

$$\text{If } P_{ERQ} < 0.0, S_{REE} = -(P_{ERQ})$$

$$\text{If } P_{ERQ} < 0.0, P_{ERQ} = 0.0$$

A flow diagram (fig. 6) shows the process area modeled in this subroutine. Note that process steam demands are shown on this diagram and also on the other process flow diagrams. Parameters calculated in this subroutine are shown in parentheses. Note that the results of this subroutine depend on previously calculated values of a variety of process parameters from other subroutines, which determine the high-, medium-, and low-pressure process steam demands.

Subroutine PWRBLR: Power boiler area

This subroutine calculates the quantities of fuels required for the power boiler furnace, the amount of sulfur dioxide in flue gases, the quantity of reclaimed salt cake, and the quantities of other process inputs in the power boiler, odor collection, and emission control area. A total of 24 data items is required for this subroutine:

- CLMC - Moisture content of coal (ratio of total weight, including moisture, average).
- COLA - Ash content of coal (ratio of dry weight).
- COLC - Carbon content of coal (ratio of dry weight, ultimate analysis).
- COLH - Hydrogen content of coal (ratio of dry weight).

- COLO - Oxygen content of coal (ratio of dry weight).
- COLN - Nitrogen content of coal (ratio of dry weight).
- COLS - Sulfur content of coal (ratio of dry weight).
- CPRC - Price of coal, f.o.b. mill, for power boiler (\$/ton as-purchased) (supply unlimited at given price).
- EXAR - Excess air admitted to power boiler furnace (decimal ratio of the theoretical minimum amount of air required for complete combustion, average).
- HVWD - Combustion heat energy of wood and bark fuels, higher heating value (Btu/pound dry weight, average).
- PCAS - Purchase price, f.o.b. mill, of caustic soda, 50% sodium hydroxide (NaOH), (\$/ton).
- PPSC - Purchase price of sodium sulfate (Na₂SO₄) salt cake for salt cake make-up (\$/ton of salt cake).
- RUHL - Radiation heat losses, unaccounted for, and miscellaneous heat losses, (decimal ratio of total heat energy input to power boiler).
- SDOR - Sulfur dioxide (SO₂) removal from stack gases in flue gas desulfurizing area (decimal ratio of total sulfur dioxide in stack gases).
- SGTP - Stack gas temperature of flue gases beyond effective heat recovery devices of power boiler (°F, average).
- STRS - Sulfur dioxide generated from incineration of "TRS gases" in power boiler (pound/ton of pulp production).
- WDMC - Moisture content of wood and bark fuels used in power boiler (decimal ratio of wet weight, average).
- WMAX - Maximum quantity of wood and bark fuel that can be used for fuel in power boiler (dry tons/day). (Coal is used for remainder of heat energy.)
- WODA - Ash content of wood and bark fuel (ratio of dry wood weight).
- WODC - Average ultimate analysis carbon content of wood and bark fuel used in power boiler (decimal ratio of wood weight).
- WODH - Hydrogen content of wood and bark fuel (ratio of dry wood weight).
- WODN - Nitrogen content of wood and bark fuel (ratio of dry wood weight).
- WODO - Oxygen content of wood and bark fuel (ratio of dry wood weight).
- WPRC - Purchase price, f.o.b. mill, of wood fuel (\$/dry ton) (or 2x selling price of surplus fuel).

Calculations for Subroutine PWRBLR are:

Calculate quantity of wood and bark residues produced and available for fuel (dry tons/day):

$$Q_{RES} = S_{RFR} + H_{RFR} + S_{BRK} + H_{BRK}$$

Calculate higher heating value of coal via Dulong formula (Btu/dry pound):

$$H_{VCO} = (145.44 \times COLC + 620.0 \times (COLH + COLO/8.0) + 41.0 \times COLS) \times 100.0$$

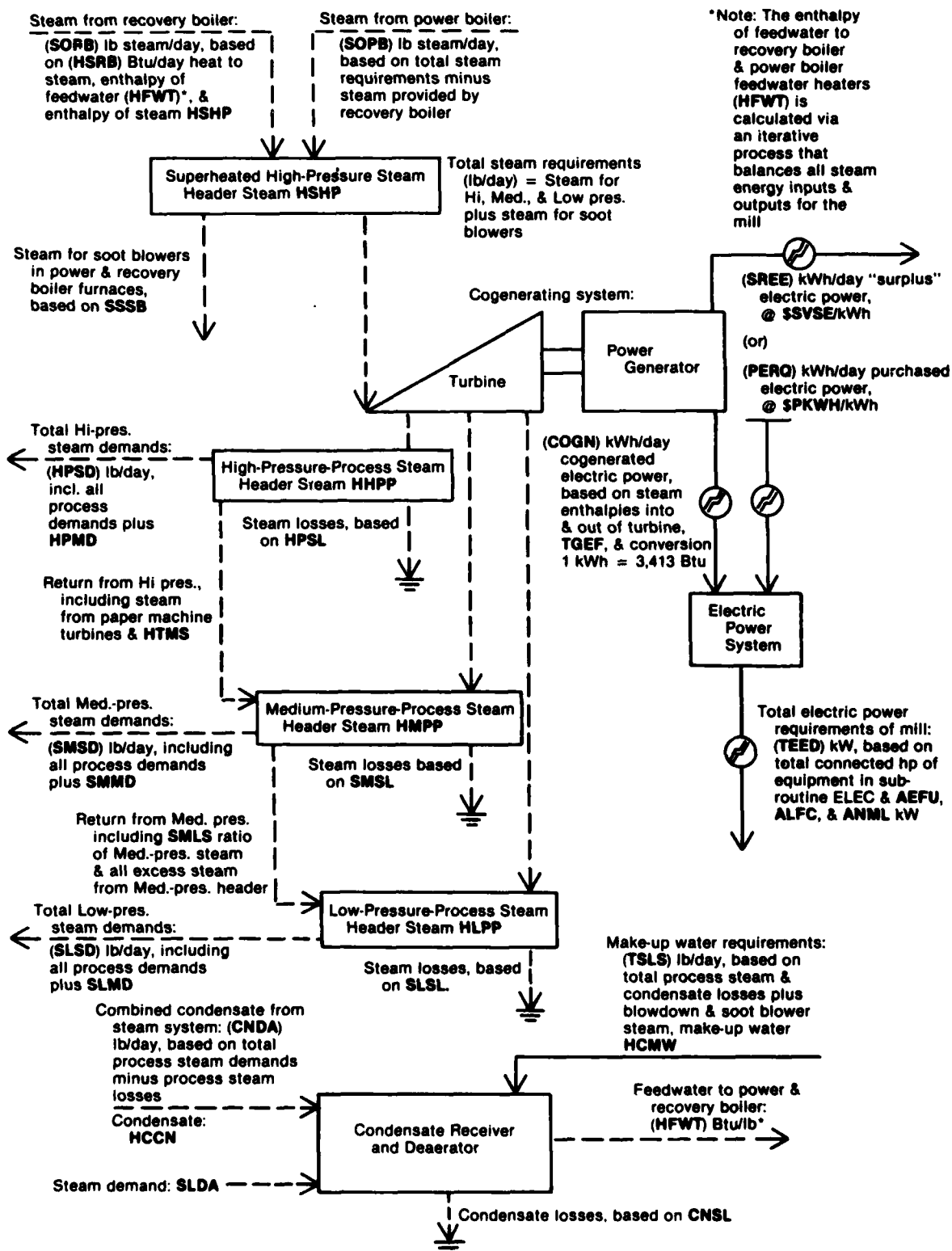


Figure 6.—Steam system, electric power and cogeneration area: Subroutine STEAM.

Calculate heat energy recovery from coal (Btu/dry ton):

Call SUB1 (HVCO, COLC, COLH, COLO, COLN, CLMC, SGTP, EXAR, RUHL, RCCO)

Calculate heat energy recovery from wood and bark fuel (Btu/dry ton):

Call SUB1 (HVWD, WODC, WODH, WODO, WODN, WDMC, SGTP, EXAR, RUHL, RCWD)

Determine total quantity of wood and bark residues and purchased wood fuel used in power boiler (dry tons):

$WM = SHDM/RCWD$

If $WM < WMAX$, $WMAX = WM$

If $QRES > WMAX$, $SURB = QRES - WMAX$

If $QRES > WMAX$, $QWOD = 0.0$

If $QRES > WMAX$, $QRES = WMAX$

$QWOD = WMAX - QRES$

If $QWOD < 0.0$, $QWOD = 0.0$

Calculate heat energy recovered from wood and bark residues, and purchased wood fuels (million Btu/day):

$HTRB = QRES \times RCWD$

$HTRW = QWOD \times RCWD$

Calculate quantity of coal required (dry tons/day):

$QCOL = (SHDM - (HTRB + HTRW))/RCCO$

If $QCOL < 0.0$, $QCOL = 0.0$

Calculate heat recovered from coal (million Btu/day):

$HTRC = QCOL \times RCCO$

Calculate quantity of sulfur dioxide in stack gases (tons/day):

$SDSG = (COLS \times QCOL \times 2.0) + (STRS \times PROD/2000.0)$

Calculate quantity of salt cake reclaimed as sodium sulfate (tons chemical/day; the factor of 2.21875 is the stoichiometric weight ratio of sodium sulfate to sulfur dioxide):

$SSDS = SDSG \times SDOR \times 2.21875$

Calculate quantity of caustic soda (50% sodium hydroxide) required for desulfurization process (tons chemical/day; the factor of 2.5 is the stoichiometric weight ratio of 2x sodium hydroxide to sulfur dioxide):

$CSDS = SDSG \times SDOR \times 2.5$

Calculate purchased salt cake requirements (tons/day of salt cake, as sodium sulfate):

$PSCR = (SCLS \times PROD/2000.0) - SSDS$

$SSCK = 0.0$

Calculate surplus salt cake produced, if any (tons/day):

If $PSCR < 0.0$, $SSCK = -PSCR$

If $PSCR < 0.0$, $PSCR = 0.0$

Calculate weight of surplus wood fuel (wet tons/day) (including moisture in fuel):

$SURB = SURB/(1.0 - WDMC)$

Calculate weight of purchased wood fuel (wet tons/day) (including moisture in fuel):

$QWOD = QWOD/(1.0 - WDMC)$

Calculate weight of purchased coal fuel (wet tons/day) (including moisture in fuel):

$QCOL = QCOL/(1.0 - CLMC)$

A further subroutine, SUB1 (HV, C, H, X, XN, PM, T2, EX, HL, RC), calculates heat energy recovery from combustion of wood, bark, or coal (million Btu/ton of dry fuel):

HV = higher heating value of fuel (Btu/pound)

C = carbon content of fuel (ratio of dry weight)

H = hydrogen content of fuel (ratio of dry weight)

X = oxygen content of fuel (ratio of dry weight)

XN = nitrogen content of fuel (ratio of dry weight)

PM = moisture content of fuel (ratio of wet weight of fuel)

T2 = stack gas temperature of combustion system beyond effective heat recovery devices

EX = excess air as a ratio of theoretical air required for combustion in furnace

HL = miscellaneous radiation and unaccounted-for heat losses, ratio of heat energy input

RC = heat recovery (million Btu/dry ton of fuel)

T1 = ambient temperature of air and fuel (= 60.0)

Calculate heat loss caused by fuel moisture and hydrogen in fuel (Btu/dry pound of fuel):

$HLMH = (970.0 + (212.0 - T1) + (0.46 \times (T2 - 212.0))) \times (H \times 9.0 + PM/(1.0 - PM))$

Calculate heat loss caused by dry gas and excess air based on specific heats of dry gases:

$HLDG = (T2 - T1) \times (0.24 \times (((H \times 8.0) + (C \times 2.667) - X)/0.232) \times EX + (((H \times 8.0) + (C \times 2.6667) - X)/0.232) \times 0.768 + XN \times 0.25 + (C \times 3.6667 \times 0.22))$

Calculate "conventional" heat losses due to radiation, miscellaneous and unaccounted-for losses:

$HLMS = HV \times HL$

Calculate heat recovery (Btu/pound of dry fuel):

$RCLB = HV - (HLMH + HLDG + HLMS)$

Calculate heat recovery (million Btu/dry ton of fuel):

$RC = RCLB \times 0.002$

A flow diagram (fig. 7) shows the process area modeled in this subroutine. Parameters calculated in this subroutine are in parentheses. Note that bark and fines removed from pulpwood in wood preparation are used as fuel in the power boiler furnace, subject to the maximum quantity of wood fuel that can be used. Note also that results of this subroutine depend on the steam energy balance calculated in the previous subroutine, which determines the quantity of steam output required from the power boiler.

Subroutine WATER: Water supply and wastewater treatment

This subroutine models the water supply system and wastewater treatment, including calculating the quantity of mill water required, the quantity of water treatment chemicals, the quantity of wastewater effluent, and the quantity of effluent treatment chemicals required. Seven items of data are required:

- EFLF - Effluent flow to wastewater treatment facilities of mill (gallons/dry ton of paper or paperboard product).
- ETCH - Effluent treatment chemicals (nutrients such as nitrogen and phosphoric compounds) (units (gallons, pounds, etc.)/thousand gallons of untreated effluent).
- PETC - Average price of effluent treatment chemicals (\$/unit (gallons, pounds, etc.)).
- PWCH - Average price of feedwater treatment chemicals (\$/unit of chemical (pounds, gallons, etc.)).
- PWTR - Price of mill water (\$/thousand gallons of water input requirements).
- WATR - Mill water requirements (gallons/dry ton of paper or paperboard product output).
- WTCH - Water treatment chemicals required (average units (pounds, gallons, etc.)/thousand gallons of water into mill).

Calculations for Subroutine WATER:

Calculate total mill water input requirements (million gallons/day):

$$TMWR = WATR \times PPRD/1000000.0$$

Calculate mill water treatment chemical requirements (units of chemicals (gallons, pounds, etc.)/day):

$$TWTC = WTCH \times TMWR \times 1000.0$$

Calculate total effluent flow to wastewater treatment (millions of gallons/day):

$$TEFL = EFLF \times PPRD/1000000.0$$

Calculate effluent treatment chemical requirements (units of chemicals (gallons, pounds, etc.)/day):

$$TETC = TEFL \times ETCH \times 1000.0$$

A flow diagram (fig. 8) shows the process area modeled in this subroutine.

Subroutine SALES: Sales revenues, material, energy, and labor costs

This subroutine calculates total process revenues, and material, energy, and labor costs (revenues and costs are calculated per year, per day, and per ton of product) based primarily on all of the process input and output calculations of the previous subroutines. A total of 13 items of data is required:

- AMLB - Average maintenance labor requirements (number of hourly wage maintenance workers needed/day (8-hr shifts each)).
- AMWG - Average maintenance labor wage rate, including all fringe benefits and related expenses (\$/hr).
- CCTC - Cost of cooling tower chemicals (cooling system for process water) (\$/ton of paper (board) product).
- CFWC - Cost of feedwater chemicals for treatment of boiler feedwater (\$/ton of paper (board) products).
- DFCS - Cost of dryer felts for paper machine dryers (\$/dry ton of product).
- DPYR - Effective number of days per year that the mill is in operation (days/year).
- EXLB - Average nonprocess labor requirements (number of hourly wage non-process workers needed/day (8-hr shifts each)).
- EXWG - Average nonprocess labor wage rate, including all fringe benefits and related expenses (\$/hr).
- PLWG - Average process labor wage rate, including all fringe benefits and related expenses (\$/hr).
- PSLB - Average process labor requirements (number of hourly wage process personnel needed/day (8-hr shifts each)).
- RCST - Cost of roll covers for finished rolls of paper or paperboard product (\$/dry ton of product).
- WCST - Cost of wires for paper machine (\$/dry ton of product).
- WFCS - Cost of wet felts for paper machine (\$/dry ton of product).

Calculations for Subroutine SALES are:

Calculate mill revenues for paper (board), turpentine, "soap," surplus electrical energy, excess reclaimed salt cake, surplus bark (\$/day):

$$R(1,1) = SVAL \times PPRD$$

$$R(2,1) = TPSV \times TRPD$$

$$R(3,1) = SOPP \times SOPR$$

$$R(4,1) = SVSE \times SREE$$

$$R(5,1) = SVSC \times SSCK$$

$$R(6,1) = (WPRC \times 0.5) \times SURB$$

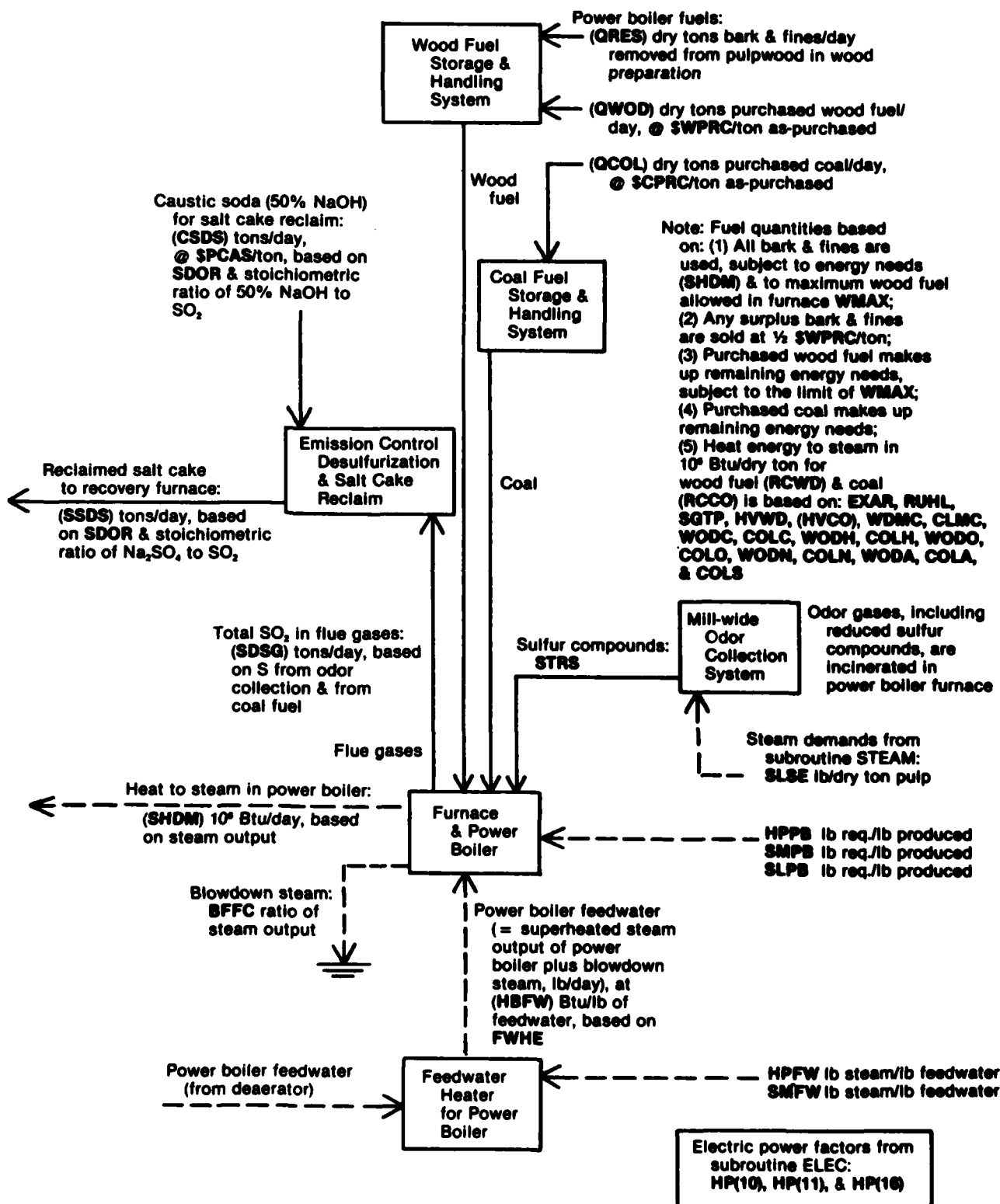
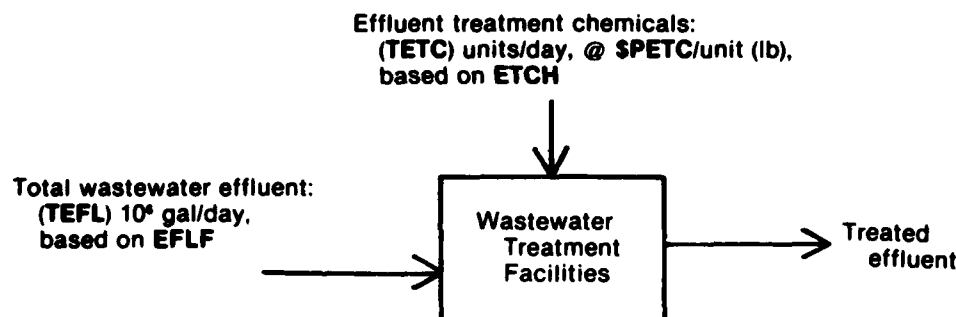
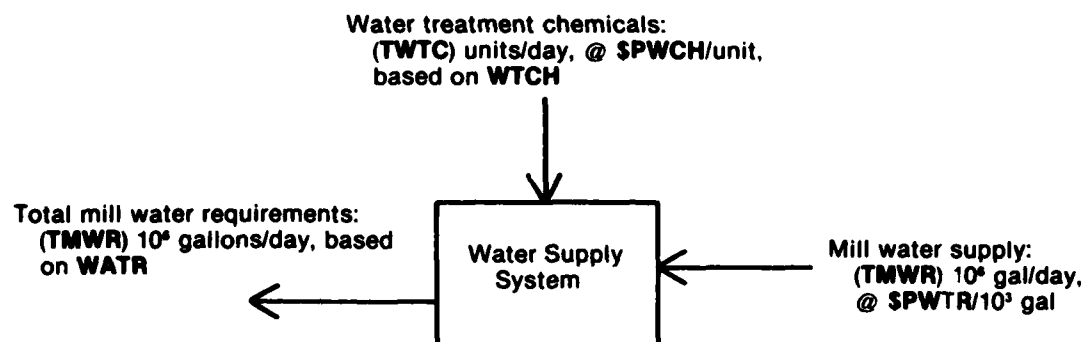


Figure 7.—Power boiler area: Subroutine PWRBLR.



Electric power factors
from subroutine ELEC:
HP(8), HP(9), & HP(15)

Figure 8.—Water supply, wastewater treatment and air supply area: Subroutine WATER.

Calculate fuel and energy costs for coal, wood fuel, natural gas, electrical energy (\$/day):

$$VC(1,1) = CPRC \times QCOL$$

$$VC(2,1) = WPRC \times QWOD$$

$$VC(3,1) = PPKF \times TKFR$$

$$VC(4,1) = PKWH \times PERQ$$

Calculate pulpwood and recycled fiber raw material costs for softwood roundwood, hardwood roundwood, softwood "clean" chips, hardwood "clean" chips, softwood whole-tree chips, hardwood whole-tree chips, recycled old corrugated, and recycled paper (\$/day):

$$VC(5,1) = PSRW \times CDSW$$

$$VC(6,1) = PHRW \times CDHW$$

$$VC(7,1) = PSPC \times SCCW$$

$$VC(8,1) = PHPC \times HCCW$$

$$VC(30,1) = PSWC \times SWCW$$

$$VC(31,1) = PHWC \times HWCW$$

$$VC(32,1) = PCOR \times RCRT$$

$$VC(33,1) = PPAP \times RPPT$$

Calculate costs of additives in stock preparation for alum, sulfuric acid, starch, defoamer, rosin, slimicide (\$/day):

$$VC(9,1) = PALM \times TALM$$

$$VC(10,1) = PACD \times TACD$$

$$VC(11,1) = PSTC \times TSTC$$

$$VC(12,1) = PDFM \times TDFM$$

$$VC(13,1) = PRSN \times TRSN$$

$$VC(14,1) = PSLM \times TSLM$$

Calculate costs of make-up and reclaim chemicals for kraft process for salt cake, lime, caustic soda for salt cake reclaim (\$/day):

$$VC(15,1) = PPSC \times PSCR$$

$$VC(16,1) = PPLM \times PLRQ$$

$$VC(17,1) = PCAS \times CSDS$$

Calculate costs of other miscellaneous chemicals for cooling tower, boiler feedwater, mill water treatment, effluent treatment (\$/day):

$$VC(18,1) = CCTC \times PPRD$$

$$VC(19,1) = CFWC \times PPRD$$

$$VC(20,1) = PWCH \times TWTC$$

$$VC(21,1) = PETC \times TETC$$

Calculate other variable costs, for roll covers, wires, wet felts, dryer felts, mill water supply (\$/day):

$$VC(22,1) = RCST \times PPRD$$

$$VC(23,1) = WCST \times PPRD$$

$$VC(24,1) = WFCS \times PPRD$$

$$VC(25,1) = DFCS \times PPRD$$

$$VC(26,1) = PWTR \times (TMWR/1000.0)$$

Calculate labor costs, for process labor, nonprocess labor, and maintenance (\$/day):

$$VC(27,1) = PSLB \times PLWG \times 8.0$$

$$VC(28,1) = EXLB \times EXWG \times 8.0$$

$$VC(29,1) = AMLB \times AMWG \times 8.0$$

Sample Program Output

Figure 9 shows a sample of the program output. The output includes material balances, steam and energy balance, electric power, fuel and chemicals summary, and a revenue and cost summary for the overall process.

The output is largely self-explanatory. The material balances show the inputs and outputs in various parts of the overall process. The steam and energy balance shows the quantities of steam and energy produced in the recovery and power boilers, and the various steam and energy demands. Note that the steam demands and losses balance with steam output of the boilers. The revenue and cost summary provides an economic interpretation of the overall process. "Contribution margin" is total revenues minus total variable costs. Contribution margin is the net amount of revenues that can be regarded as available to cover fixed costs and capital costs, with the remaining amount available for earnings or profit. Taxes are not considered here. Note also that the variable costs include some items, particularly labor, that are probably "semivariable" in a strict sense. That is, as level of production increases or decreases, labor cost and other "semivariable" costs will not change in direct proportion.

The sample data values presented in the appendix were used to obtain the output in figure 9.

User Notes, Guidelines, and Summary

A complete listing of the sample data and the program are provided in the appendix. Data are read sequentially by each subroutine. The program uses the input format corresponding to the data list in the appendix, and includes complete output format corresponding to the output shown in figure 9.

The mathematical procedures used in the model were designed to be simple and straightforward, although the overall process is complex. The model and sample data were verified by comparison with physical parameters and estimated cost data provided by a consulting engineering firm that has been involved recently in design and installation of unbleached kraft paperboard mills. The model and sample data correspond to modern mill and process design criteria as verified in informal contacts with numerous industry personnel and reviews of numerous trade journal articles describing features of specific modern mills. The model has also been tested at a variety of extreme parameter values and appears to provide reasonable and satisfactory results.

The computer model permits a user to make quick, precise estimates of the effects of major economic, technological, or physical changes in an overall conventional unbleached kraft paperboard production process. With the model, users can develop their own basic set of data that reflects their concept of conventional process design and conventional process parameters. Then the user may adjust the basic set of data to reflect a specific process or economic change, and can obtain precise estimates of the effect of that change in a matter of minutes, using the computer model. The model is also inexpensive to run. Thus it is useful in evaluating research opportunities, process alternatives, and the results of applied technical research on the unbleached kraft paperboard process.

One final word of caution is necessary. The user must keep in mind that changes in one or several of the data parameters might necessitate changes in other data parameters. For example, if pulp yield is changed, it is probably true that the amount of black liquor recovered per ton of pulp will need to be changed also. Other data parameters can also be affected. Therefore, the user needs to have some familiarity with the overall process and with the way in which various data parameters are likely to be related to each other. A general rule to follow in using the model is the following: Whenever changes are made in any of the data, review all of the data to see if corresponding changes must be made in other values too. After a user develops familiarity with the model, that procedure will likely become second nature.

MATERIALS BALANCE

I. STOCK PREPARATION, ADDITIVES, PAPER MACHINE, FINISHING AND SHIPPING AREAS

A. FINISHED PRODUCT OUTPUT:

1400.0 DRY TONS/DAY
(MOISTURE CONTENT 6.0 % TOTAL WT. BASIS)
(1400.0 TONS/DAY, GROSS PRODUCT OUTPUT AIR DRY WT.)
(80.0 TONS/DAY, WATER IN PRODUCT)

B. RECYCLED DRY BROKE (TO STOCK PREP.):

35.0 DRY TONS/DAY

C. TOTAL PAPER MACHINE AND DRYER THROUGHPUT (A + B):

1435.0 DRY TONS/DAY
(TRIMMED REEL WIDTH: 324. INCHES)
(AVERAGE SPEED: 1437. LIN. FT./MIN.)
(MAXIMUM SPEED: 1714. LIN. FT./MIN.)

D. ADDITIVES AND RECYCLED MATERIALS IN STOCK PREPARATION:

14.0 TONS/DAY ALUM
10.0 TONS/DAY ACID
.0 TONS/DAY STARCH
1.2 TONS/DAY DEFOAMER
1.0 TONS/DAY ROSIN
.0 TONS/DAY GLIMICIDE
.0 DRY TONS/DAY RECYCLED CORRUGATED
.0 DRY TONS/DAY RECYCLED PAPER

E. TOTAL WEIGHT ADDITIVES AND RECYCLED MATERIALS IN PRODUCT (INCLUDES ALL RECYCLED AT RECOVERY RATE, ALL ALUM, STARCH, ROSIN, PLUS HALF OF ACID, DEFOAMER, & GLIMICIDE)

23.3 DRY TONS/DAY

F. WEIGHT OF PULP INTO STOCK PREPARATION FROM DIGESTER (A - E):

1376.7 DRY TONS/DAY

G. WATER REMOVAL IN DRYER SECTION:

2060.9 TONS/DAY
(AVG. MOIST. CONT. INTO DRYER 60.0 % TOTAL WT.)
(AVG. MOIST. CONT. OUT OF DRYER 6.0 % TOTAL WT.)

III. WOOD PREPARATION AREAS

A. VOLUME OF PULPHOOD INTO DIGESTER (II.B):

2573.3 DRY TONS/DAY

B. VOLUME OF BARK AND FINES REMOVED AND ROUTED TO POWER BOILER

330.6 DRY TONS/DAY

C. TOTAL VOLUME OF PULPHOOD REQUIRED INCLUDING BARK AND FINES (SEE BELOW *):

2904.0 DRY TONS/DAY

* AVG. QUANTITY OF SOFTWOOD ROUNDWOOD PULPHOOD REQUIRED PER DAY:

1150.5 DRY TONS/DAY, OR
671.3 CORDS/DAY

(MOISTURE CONTENT: 50.0%)

904.3 DRY TONS/DAY TO DIGESTER
150.1 DRY TONS/DAY BARK
20.1 DRY TONS/DAY FINES

* AVG. QUANTITY OF HARDWOOD ROUNDWOOD PULPHOOD REQUIRED PER DAY:

337.6 DRY TONS/DAY, OR
230.4 CORDS/DAY

(MOISTURE CONTENT: 50.0%)

200.5 DRY TONS/DAY TO DIGESTER
42.2 DRY TONS/DAY BARK
9.9 DRY TONS/DAY FINES

* AVG. QUANTITY OF "CLEAN" SOFTWOOD CHIPS REQUIRED PER DAY:

372.1 DRY TONS/DAY, OR
700.1 TONS/DAY, AS RECEIVED

(MOISTURE CONTENT: 50.0%)

360.0 DRY TONS/DAY TO DIGESTER
11.2 DRY TONS/DAY FINES

II. DIGESTER, PULP WASHING AND EVAPORATORS

A. WEIGHT OF PULP OUT OF WASHERS (I.F.):

1376.7 DRY TONS/DAY

B. PULPHOOD CHIPS INTO DIGESTER:

2573.3 DRY TONS/DAY

C. TURPENTINE RECOVERY FROM CHIPS:

3.5 TONS/DAY

D. BLACK LIQUOR SOLIDS IN WEAK BLACK LIQUOR FROM WASHERS TO EVAPORATORS

1005.5 TONS DRY SOLIDS/DAY
(SOLIDS CONTENT: 15.0 %)

E. SOAP RECOVERY FROM BLACK LIQUOR:

100.1 DRY TONS/DAY

F. WATER REMOVALS IN EVAPORATORS & CONCENTRATORS:

6522.5 TONS/DAY WATER REM. IN EVAPORATORS
(SOLIDS CONTENT TO CONCENTRATORS: 50.0 %)

703.4 TONS/DAY WATER REM. IN CONCENTRATORS:
(SOLIDS CONTENT TO RECOVERY BOILER: 65.0 %)

G. BLACK LIQUOR CONCENTRATE TO RECOVERY BOILER:

1607.4 TONS DRY SOLIDS/DAY

H. WHITE LIQUOR TO DIGESTER:

900.0 THOUSAND GALLONS/DAY
373.1 TONS/DAY ACTIVE ALKALI
(SODIUM OXIDE EQUIVALENT)
(10.5 % OF WOOD WEIGHT)

* AVG. QUANTITY OF "CLEAN" HARDWOOD CHIPS REQUIRED PER DAY:

30.8 DRY TONS/DAY, OR
70.6 TONS/DAY, AS RECEIVED

(MOISTURE CONTENT: 50.0%)

30.0 DRY TONS/DAY TO DIGESTER
1.2 DRY TONS/DAY FINES

* AVG. QUANTITY OF SOFTWOOD WHOLE-TREE CHIPS REQUIRED PER DAY:

935.7 DRY TONS/DAY, OR
1071.4 TONS/DAY, AS RECEIVED

(MOISTURE CONTENT 50.0%)

842.1 DRY TONS/DAY TO DIGESTER
93.0 DRY TONS/DAY FINES

* AVG. QUANTITY OF HARDWOOD WHOLE-TREE CHIPS REQUIRED PER DAY:

60.3 DRY TONS/DAY, OR
120.7 TONS/DAY, AS RECEIVED

(MOISTURE CONTENT 50.0%)

57.9 DRY TONS/DAY TO DIGESTER
0.0 DRY TONS/DAY FINES

Figure 9.—Sample program output 1,400 T.P.D. Conventional process; 1982 Price data.

STEAM AND GROSS ENERGY BALANCE

	MILLION POUNDS OF STEAM		HEAT ENERGY		
	PER DAY	PER HR.	-----MILLION B.T.U.-----	PER DAY	PER TON
STEAM OUTPUT:					
POWER BOILER	10.923	.455	15543.9	647.7	11.103
RECOVERY BOILER	12.561	.523	17875.0	744.0	12.760
TOTAL STEAM OUTPUT	23.485	.979	33418.9	1392.5	23.871

STEAM DEMANDS:

SUPERHEATED STEAM (1423.0 B.T.U./LB.)

BOOTHLOWERS	.737	.031	1068.7	43.7	.749
TURBINE GENERATORS (NET ENERGY)	--	--	3190.5	133.3	2.285

HIGH PRESSURE PROCESS (1381.6 B.T.U./LB.)

PAPER MACH. & VAC. TURBINES	4.430	.185	6131.5	255.5	4.380
PAPER MACH. THERMOCOMPRESS.	1.302	.054	1798.0	75.0	1.285
REC. BOILER AIR HEATERS	.516	.021	710.6	29.0	.500
POWER BOILER FEEDWATER MTR.	1.253	.052	1731.0	72.1	1.236
POWER BOILER MISCELLANEOUS	.000	.000	.0	.0	.000
MISC. HIGH PRESSURE STEAM	.000	.000	.0	.0	.000

MEDIUM PRESSURE PROCESS (1279.2 B.T.U./LB.)

PAPER MACHINE DRYERS	6.059	.252	7750.7	322.9	5.536
DIGESTER LIQUOR HEATER	1.270	.053	1624.0	67.7	1.160
EVAPORATOR STEAM JETS	.074	.003	98.0	4.0	.060
AIR SUPPLY AREA	.000	.000	7.9	.3	.000
EMISSIONS CONTROL, REC. BLR.	.104	.004	135.7	5.7	.097
AIR HEATERS, REC. BLR.	1.044	.043	1335.3	55.4	.954
DISSOLVING TANK	.080	.003	101.8	4.2	.073
SEC. BLACK LIQ. MTR.	.123	.005	157.6	6.6	.113
BLACK LIQ. GUMS, REC. BLR.	.064	.003	84.7	3.5	.060
POWER BOILER FEEDWATER MTR.	.543	.023	695.0	29.0	.490
POWER BOILER AREA MISC.	.000	.000	.0	.0	.000
MISC. MED. PRESSURE STEAM	.000	.000	.0	.0	.000
(STEAM FROM HIGH PRESSURE PROCESS)	(5.788)	(.241)	(7404.6)	(309.5)	(5.289)

LOW PRESSURE PROCESS (1219.6 B.T.U./LB.)

PAPER MACHINE AUX. EQUIP.	2.600	.117	3016.3	122.3	2.439
GREEN LIQUOR HEATER	.553	.025	650.5	27.0	.508
AIR HEATERS, REC. BLR.	.429	.018	523.0	21.0	.374
EVAPORATORS (BLACK LIQUOR)	3.307	.138	4032.2	160.0	2.004
CONCENTRATORS (BLACK LIQUOR)	1.042	.043	1270.5	52.9	.908
DIGESTER STEAMING VESSEL	.715	.030	872.3	36.3	.623
ODOR CONTROL SYSTEM	1.155	.048	1408.5	58.7	1.006
POWER BOILER AREA MISC.	.000	.003	70.9	3.3	.057
DEAERATOR (FEEDWATER)	2.231	.093	2720.7	113.4	1.903
MISC. LOW PRESSURE STEAM	.000	.000	.0	.0	.000
(STEAM FROM MED. PRESSURE PROCESS)	(.440)	(.018)	(537.1)	(22.4)	(.304)

TOTAL STEAM DEMANDS

23.485 .979 33418.9 1392.5 23.871

MAKE-UP WATER REQUIRED

4.617 .104 -- -- --

FEEDWATER ENTHALPY

269.0 B.T.U./LB.

NET STEAM ENERGY BALANCE

	HEAT ENERGY		
	-----MILLION B.T.U.-----	PER DAY	PER TON
NET ENERGY ADDED TO STEAM SYSTEM, IN:			
DEAERATOR & MAKE-UP WATER	2204.	92.	1.97
POWER BOILER FEEDWATER HEATER	2010.	84.	1.40
POWER BOILER	10574.	441.	7.55
RECOVERY BOILER	14460.	603.	10.33
TOTAL NET ENERGY	29262.	1219.	20.90
NET ENERGY SUBTRACTED FROM STEAM SYSTEM, IN:			
SUPERHEATED STEAM			
BOOTHLOWERS	1069.	44.	.75
TURBINE GENERATORS	3200.	133.	2.20
HIGH PRESSURE PROCESS			
PAPER MACHINE TURBINES	454.	19.	.32
STEAM TO MEDIUM PRESSURE PROCESS	130.	6.	.10
STEAM TO CONDENSATE	2010.	84.	1.40
STEAM LOSSES	0.	0.	.00
MEDIUM PRESSURE PROCESS			
STEAM TO LOW PRESSURE PROCESS	20.	1.	.02
STEAM TO CONDENSATE	873.	36.	0.54
STEAM LOSSES	078.	41.	.70
LOW PRESSURE PROCESS			
STEAM TO CONDENSATE	9465.	415.	7.12
STEAM LOSSES	2715.	113.	1.94
TOTAL NET ENERGY	29270.	1220.	20.91

(NOTE: TOTALS MAY NOT AGREE PRECISELY)

ENTHALPY OF VARIOUS FLOWS

IN THE STEAM SYSTEM

ENTHALPY (B.T.U./LB.)

COMBINED CONDENSATE (INTO CONDENSATE RECEIVER FROM PROCESS)	210.0
MAKE-UP WATER (INTO DEAERATOR)	40.0
PRIMARY FEEDWATER (TO REC. BOILER AND P.B. FEEDWATER HEATERS)	269.0
FEEDWATER TO POWER BOILER (FROM P.B. FEEDWATER HEATERS)	451.0
SUPERHEATED STEAM (FROM BOILERS, TO TURBINE)	1423.0
HIGH PRESSURE PROCESS STEAM (FROM TURBINE)	1381.6
MED. PRESSURE PROCESS STEAM (FROM TURBINE)	1279.2
LOW PRESSURE PROCESS STEAM (FROM TURBINE)	1219.6

Figure 9.—Sample program output 1,400 T.P.D. Conventional process; 1982 Price data (continued).

REVENUES, COSTS, PROFIT CONTRIBUTION

	S/DAY	S/DRY TON	S-ANNUAL
REVENUES			
PAPERBOARD PRODUCT (0 \$276.00/DRY TON)	406000.	270.00	104130000.
TURPENTINE (0 \$.00/GALLON)	800.	.01	301000.
TALL OIL SOAP (0 \$ 60.00/TON)	7210.	5.10	2562000.
TOTAL REVENUES	414010.	275.76	106993000.

PULPWOOD COSTS			
SOFTWOOD ROUNDWOOD (0 \$ 55.00/CORD)	47021.	34.23	17011973.
HARDWOOD ROUNDWOOD (0 \$ 36.00/CORD)	8240.	5.03	2905134.
"CLEAN" SOFTWOOD CHIPS (0 \$ 20.00/TON)	20034.	10.00	7304750.
"CLEAN" HARDWOOD CHIPS (0 \$ 21.00/TON)	1071.	1.19	503322.
SOFTWOOD WHOLE-TREE CHIPS (0 \$ 10.00/TON)	33605.	20.00	11950078.
HARDWOOD WHOLE-TREE CHIPS (0 \$ 10.00/TON)	2059.	1.47	730022.

LABOR COSTS			
PROCESS LABOR (0 \$ 13.45/HR.)	25024.	10.45	9167520.
NON-PROCESS LABOR (0 \$ 11.00/HR.)	4084.	5.20	1591000.
MAINTENANCE LABOR (0 \$ 12.27/HR.)	9227.	4.50	3275500.

FUEL AND ENERGY COSTS			
COAL (0 \$ 49.00/TON)	11556.	8.25	4102550.
WOOD FUEL (0 \$ 12.00/TON)	14201.	10.17	1055073.
NAT. GAS (0 \$ 4.00/MCF)	8750.	0.20	3102030.
PURCHASED ELECTRIC (0 \$.031/KWH)	19120.	0.00	4300050.

MAKE-UP AND SALTCAKE RECLAIM CHEMICAL COSTS			
SALTCAKE MAKE-UP (0 \$ 80.00/TON)	273.	.20	97022.
LINE MAKE-UP (0 \$ 60.00/TON)	707.	.50	250400.
CAUSTIC SODA FOR RECLAIM (0 \$300.00/TON-50%)	7579.	5.27	2619050.

ELECTRIC POWER, FUELS, CHEMICALS

ELECTRIC POWER BALANCE		
TOTAL ELECTRIC POWER CONSUMED	1090267.	KWH/DAY
ELECTRIC POWER COGENERATED	703000.	KWH/DAY
PURCHASED ELECTRIC POWER	391173.	KWH/DAY
SURPLUS ELECTRIC POWER	0.	KWH/DAY

FUEL REQUIREMENTS

FOR POWER BOILER FURNACE		
COAL	150.1	DRY TONS/DAY
PURCHASED WOOD FUEL	593.4	DRY TONS/DAY
WOOD RESIDUES	330.6	DRY TONS/DAY

FOR LINE KILN		
NAT. GAS	2104.5	MCF/DAY

LINE BALANCE

LINE CONSUMED IN BLANKING & CAUSTIZING	294.54	TONS/DAY
LINE PRODUCED IN LINE KILN	202.76	TONS/DAY
PURCHASED MAKE-UP LINE	11.70	TONS/DAY

SALTCAKE BALANCE

NET SALTCAKE LOADED (EXCLUDING RECOVERY FROM POWER BOILER DESULFURIZING)	20.691	TONS/DAY
SALTCAKE RECOVERED IN POWER BOILER DESULFURIZING	17.235	TONS/DAY

BASED ON:

10.257 TONS/DAY SULFUR DIOXIDE IN FLUE GASES
.750 REMOVAL RATIO

PURCHASED SALTCAKE REQUIRED 3.416 TONS/DAY

CAUSTIC SODA (50 PCT. SODIUM HYDROXIDE) REQUIRED FOR DESULFURIZING 19.419 TONS CHEMICAL/DAY

STOCK PREP. AND PAPER MACHINE ADDITIVES COSTS

ALUM (0 \$ 130.00/TON)	1020.	1.30	646100.
SULFURIC ACID (0 \$ 74.00/TON)	1003.	.77	304330.
STARCH (0 \$ 240.00/TON)	0.	.00	0.
DEFOAMER (0 \$ 500.00/TON)	1023.	.73	363307.
ROBIN (0 \$ 500.00/TON)	000.	.03	216100.
SLIMICIDE (0 \$ 500.00/TON)	502.	.39	102330.

OTHER MISCELLANEOUS CHEMICALS COSTS

COOLING TOWER CHEMICALS	50.	.00	10000.
BOILER FEEDWATER CHEMICALS	154.	.11	90070.
WATER TREATMENT CHEMICALS	00.	.03	10351.
EFFLUENT TREATMENT CHEMICALS	570.	.01	205400.

OTHER VARIABLE COSTS

FINISHED ROLL COVERS	160.	.12	90600.
PAPER MACHINE WIRES	1004.	.76	377720.
NET FELTS	1500.	1.12	550000.
DRYER FELTS	1100.	.02	407500.

TOTAL VARIABLE COSTS	210070.	156.34	77701032.
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CONTRIBUTION MARGIN	195100.	139.42	69291976.
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Figure 9.—Sample program output 1,400 T.P.D. Conventional process; 1982 Price data (continued).

Appendix Program Data and Program Listing

Note in the data listing that each numerical item of data is described by the line directly above it. For example, the numerical value of 20.9 corresponds to the data parameter ACID. Each numerical value can be entered in the first 20 columns of the line following its description in the data listing. Note also at the top of the data listing the parameter 'NX' which controls the amount and type of program output.

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1. 1400 T.P.O.
2. LIMEBOARD MILL
3. CONVENTIONAL PROCESS
4. 1942 PRICE DATA
5. NX-OUTPUT SPEC (1-11,111,STEAM,SALES),(2-1,111,STEAM,SALES),(3-1,11,STEAM,SALES)
6. 13 (4-1,11,111,SALES),(5-1,SALES),(6-STEAM,SALES),(7-11,111,STEAM,SALES,POWER),(8-1,111,STEAM,SALES,POWER),(9-1,11,STEAM,SALES,POWER),(10-1,111,SALES,POWER),(11-1,SALES,POWER),(12-STEAM,SALES,POWER),(13-ALL)
7.
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11. DATA FOR STREP SUBROUTINE
12.
13. ACID - QUAN CONCEN SULFURIC ACID ADDED--LBS ACID/DRY TON PAPER ON PAPERBOARD
14. 20.9
15. ALUM--QUAN ALUM ADDED IN STK PREP--LBS ALUM SOLID/DRY TON PAP OR BOARD PRODUCT
16. 20.8
17. DMT--DRY BRONE RECYCLED TO STOCK PREP--RATIO TO TOTAL PAPER OR BOARD PRODUCT
18. 0.025
19. DFM--QUAN DEFOAMER ADOTVS IN STK PREP--LBS/DRY TON PAPER OR PAPERD PRODUCED
20. 1.7
21. DMC--M.C. SHEET ENTERING THERMAL DYER SECTION--RATIO TO TOTAL WEIGHT OF SHEET
22. 0.00
23. PACD--PURCHASE PRICE OF SULFURIC ACID--$/TON F.O.B. MILL
24. 74.0
25. PALM--PURCHASE PRICE OF ALUM--$/TON F.O.B. MILL
26. 130.0
27. PCOR - PRICE OF RECYCLED OLD CORRUGATED AS RAW MAT FURN IN STPREP, $/DRY TON
28. 55.0
29. POFM--PURCHASE PRICE OF DEFOAMER--$/TON F.O.B. MILL
30. 600.0
31. PHMD--MINIMUM DENSITY OF PAPER ON PAPERD PROD--DRY LBS/1000 SQUARE FEET
32. 42.0
33. PPAP - PRICE OF OTHER RECYCLED PAPER RAW MATERIAL IN STPREP, $/DRY TON
34. 12.0
35. PPDH--AUG DENSITY PAPER ON PAPERD PROD--DRY LBS/1000 SQUARE FEET PAPER ON BOARD
36. 50.1
37. PHMC--AUG MISTURE CONTENT OF SHEET OUT OF DYERS--TOTAL WEIGHT BASIS
38. 0.00
39. PRPD--PAPER ON PAPERBOARD PRODUCTION VOLUME--DRY TONS OF PAP OR PAPERD/DAY
40. 1400.0
41. PRSH--PURCHASE PRICE OF ROBIN, $/TON F.O.B. MILL
42. 540.0
43. PRLM--PURCHASE PRICE OF BLIMPIDE, $/TON F.O.B. MILL
44. 400.0
45. STIC--PURCHASE PRICE OF STARCH, $/TON F.O.B. MILL
46. 240.0
47. RCOR--RECY OLD CORRUGATED FIBER--WEIGHT RATIO CORR. FIBER/TOTAL PULP
48. 0.00
49. RCTO--RECOVERY RATE OLD CORR, RATIO RAW MATERIAL WEIGHT RECOVERED IN PRODUCT
50. 0.92
51. ROBN--QUAN ROBIN ADDED IN STK PREP--LBS ROBIN SOLIDS/DRY TON PAP OR PAPERD PROD
52. 1.5
53. RPSD--OTHER RECY PAPER FIBER--WEIGHT RATIO OF OTHER RECY FIBER/TOTAL PULP
54. 0.00
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1050.0	MP(13)--WASHING AND REFINING AREA
1710.0	MP(14)--STOCK PREPARATION AREA
1824.0	MP(15)--PAPER MACHINE AREA
1697.0	MP(16)--ADDITIVES AREA
128.0	MP(17)--FINISHING AND SHIPPING AREA
32.0	MP(18)--WATER SUPPLY AND TREATMENT AREA
1274.0	MP(19)--WASTE DISPOSAL AREA
1889.0	MP(110)--POWER BOILER AREA
8937.0	MP(111)--COAL HANDLING AREA
438.0	MP(112)--RECOVERY BOILER AREA
4784.0	MP(113)--EVAPORATORS AREA
1870.0	MP(114)--LINE KILN AND RECAUSTIZING AREA
3005.0	MP(115)--AIR SUPPLY SYSTEM
3000.0	MP(116)--DOOR COLLECTION SYSTEM
4672.0	ALFC-AVERAGE POWER LOAD FAC/HILL EQUIP--DEC RATIO OF CONNECTED HORSEPOWER
0.50	APFU-AVG EFFICIENCY OF ELECTRICITY USE IN MILL EQUIP--DEC RATIO OF ELEC ENGY DEM
0.00	ANML-AVG NON-MOTOR LOAD, LIGHTING AND MISCELLANEOUS--KILOWATTS
4000.0	DATA FOR STEAM SUBROUTINE
0.015	HPFC-BLOWDOWN RATIO FOR PHR AND RECLRS--LBS BLOWN/TOT LBS STEAM PRODUCED
0.0106	CHBL--LOSSES FROM STEAM SYSTEM IN CONDENSATE RECEIVER AND DEAERATOR
0.0106	FINE-FOUNT MTR HEAT EXCHANGE EFFIC--RATIO HEAT INPUT EXITING FEEDWATER/AVERAGE
0.905	MCEN--ENTHALPY OF COMBINED CONDENSATE STEAM SYS TO DEAERATOR--BTU/LB CONDENSATE
210.0	MCEN--ENTHALPY OF MAKE-UP WATER TO DEAERATOR--BTU/LB MAKE-UP WATER
40.0	MHP--ENTHALPY OF HIGH PRESSURE PROCESS STEAM--BTU/LB STEAM
1301.0	MHP--ENTHALPY OF LOW PRESSURE PROCESS STEAM--BTU/LB STEAM
1219.0	MHP--ENTHALPY OF MEDIUM PRESSURE PROCESS STEAM--BTU/LB STEAM
1279.2	MHP--ENTHALPY OF SUPERHEATED STEAM FROM BOILERS, BTU/LB STEAM
1823.0	MHS--RATIO TOT HIGH PRES PROC STEAM REC AS MED PROC STEAM, ETC STEAM FROM TURRINE
0.44	PAHM--PRICE OF PURCHASED ELECTRIC ENERGY, \$/KILOWATT HOUR
0.031	SLCS--RATIO TOT MED PRES PROC STEAM REC AS LOW PROC STEAM, ETC STEAM FROM TURRINE
0.047	SPSU--SUPERMTO STEAM REQ BOOTLURS IN PHR RECLRS--LBS STEAM/TOT LBS STEAM PROD
0.00130	RECLRS--VAL SURPLUS ELEC ENGY COGENERATED IN MILL--\$/KILOWATT HOUR
0.00	TEGT--TURBINE GENERATOR EFFICIENCY FOR CONVERT TURBINE ENERGY TO ELECT ENERGY
0.75	MPAH--HIGH PRES STEAM AIR MTR IN RECLR--LBS STEAM/TON BLK LIO SOLIDS TO RECLR
303.0	MPH--HIGH PRES STEAM DEMAND PHBLR FOUTR MTR--LBS STEAM/LB FOUTR TO PHBLR
0.113	MPHD--HIGH PRES STEAM MISC DEMAND VOLUME--LBS STEAM/TON PROD
0.00	MPHR--HIGH PRES STEAM DEMAND PHBLR, AIR MTR--LBS STEAM/LB STEAM PROD PHRS
0.00	MPHM--HIGH PRES STEAM DEMAND PAP MACH--TURBINES--LBS STEAM/DRY TON PAP OR PAPPD
3170.0	MPBL--LOSSES FROM HIGH PRES STEAM SYS--RATIO TOT HIGH PRES NOT RET IN CONDENSATE
0.00	MPIC--HIGH PRES STEAM DEMAND PAP MACH THERMOCOMPRESSORS--LBS STEAM/DRY TON PAPER
0.15.0	SNAM--MED PRES STEAM DEM AIR MTR RECLR--LBS STEAM/TON BLK LIO SOLIDS TO RECLR
0.00	SNAM--MED PRES STEAM DEM AIR SPLY AREA--LBS STEAM/DRY TON PULP PRODUCED
0.00	SNAM--MED PRES STEAM DEM AIR SPLY AREA--LBS STEAM/DRY TON PULP PRODUCED


```

C *** PMNO - MINIMUM DENSITY OF PAPER OR PAPERBOARD PRODUCT IN DRY
C *** POUNDS PER THOUSAND SQUARE FEET.
C *** PPAP - PRICE OF RECYCLED PAPER, USED AS RAW MATERIAL IN STOCK
C *** PREPARATION, DOLLARS PER DRY TON.
C *** PPDM - AVERAGE DENSITY OF PAPER OR PAPERBOARD PRODUCT IN DRY
C *** POUNDS PER THOUSAND SQUARE FEET OF PAPER OR BOARD.
C *** PPMC - AVERAGE REEL THOUSAND CONTENT OF PAPER OR PAPERBOARD
C *** PRODUCT, TOTAL WEIGHT BASIS.
C *** PPBD - PAPER OR PAPERBOARD PRODUCTION VOLUME OF THE MILL, IN DRY
C *** TONS OF PAPER OR PAPERBOARD PER DAY.
C *** PPSN - PURCHASE PRICE OF ROSIN ($/TON FOR MILL).
C *** PSLM - PURCHASE PRICE OF SLIMCIDE ($/TON FOR MILL).
C *** PSTC - PURCHASE PRICE OF STARCH ($/TON FOR MILL).
C *** RCOR - RECYCLED OLD CORRUGATED RAW MATERIAL AS A RATIO OF
C *** TOTAL WEIGHT OF PAPER(BOARD) PRODUCT, DECIMAL RATIO OF
C *** DRY PRODUCT WEIGHT. RECYCLED FURNISH CENTRAL IN STOCKPREP.
C *** RCYO - YIELD OR RECOVERY WEIGHT FOR RECYCLED OLD CORRUGATED.
C *** RATIO OF RAW MATERIAL DRY WEIGHT RECOVERED IN PRODUCT.
C *** ROSN - QUANTITY OF ROSIN ADDED IN STOCK PREPARATION, IN POUNDS OF
C *** ROSIN SOLIDS PER DRY TON OF PAPER OR PAPERBOARD PRODUCED.
C *** RPAP - RECYCLED PAPER RAW MATERIAL AS A RATIO OF TOTAL WEIGHT
C *** OF PAPER(BOARD) PRODUCT, DECIMAL RATIO OF DRY PRODUCT
C *** WEIGHT.
C *** RPVO - YIELD OR RECOVERY RATE FOR RECYCLED PAPER RAW MATERIAL,
C *** RATIO OF RAW MATERIAL DRY WEIGHT RECOVERED IN PRODUCT.
C *** SLIM - QUANTITY OF SLIMCIDE ADDITIVES PER DRY TON OF PAPER OR
C *** PAPERBOARD PRODUCED, POUNDS OF ADDITIVES PER DRY TON OF
C *** PRODUCT.
C *** STRC - QUANTITY OF STARCH ADDITIVES IN STOCK PREPARATION, IN
C *** POUNDS OF DRY STARCH SOLIDS PER DRY TON OF PAPER (BOARD)
C *** PRODUCT.
C *** SVAL - AVERAGE SALES VALUE OF PAPER OR PAPERBOARD PRODUCT, IN
C *** DOLLARS PER DRY TON, F.O.B. MILL.
C *** TMO - TRIMMED REEL WIDTH ON SHEET ROLL WINDER.
C *** READ STATEMENTS!
C ***
C *** READ (5,1)ACID,ALUM,DRNT,OFDM,OSMC,PACD,PALM,PCOR,PPDM,
C *** PPMO,PPBD,PPDM,PPMC,PPRO,PSRM,PSLM,PSTC,RCOR,RCYO,ROSN,
C *** RPAP,RPVO,SLIM,STRC,SVAL,TMO
C ***
C *** 10 FORMAT (////26(P20.0)))
C ***
C *** CALCULATIONS!
C ***
C *** CALCULATE TOTAL DRY WEIGHT OF CHEMICAL AND SIZING ADDITIVES IN
C *** POUNDS PER DRY TON IN PRODUCT, ASSUMING ALL OF ALUM, STARCH, AND
C *** ROSIN ADDITIVES ARE IN FINAL PRODUCT, PLUS ONE-HALF OF ACID,
C *** DEFOAMER AND SLIMCIDE ADDITIVES. BY WEIGHT.
C *** ADTV = ALUM + STRC + ROSN + 0.5 * (ACID + OFDM + SLM)
C *** CALCULATE QUANTITY OF RECYCLED OLD CORRUGATED USED, DRY TONS PER
C *** DAY
C *** IF (RCYO,LE,0.0) GO TO 20
C *** IF (RPVO,LE,0.0) GO TO 20
C *** RCPT = RCOR * ((PPRO)-(PPRO*ADTV/2000.0))/(RCYO)
C *** CALCULATE QUANTITY OF RECYCLED PAPER USED, DRY TONS PER DAY!
C *** RPPT = RPAP * ((PPRO)-(PPRO*ADTV/2000.0))/(RPVO)
C ***
C *** 20 CONTINUE
C *** CALCULATE PULP PRODUCTION QUANTITY REQUIRED, IN DRY TONS OF PULP
C *** PER DAY:
C *** PPMO = PPMO - (PPRO * ADTV/2000.0) - (RCYO*RCYO) - (RPPT*RPPT)
C *** IF (PPRO,LE,0.0) PPMO = 0.0
C *** CALCULATE TOTAL DRY PAPER THROUGHPUT OF PAPER MACHINE IN DRY TONS
C *** PER DAY, INCLUDING PRODUCT PLUS DRY BROKE AND DRY TRIMS VOLUME
C *** THAT ARE RECYCLED:
C *** TOTP = PPMO + (PPRO * OSMT)
C *** CALCULATE AVERAGE OPERATIONAL PAPER MACHINE SPEED IN LINEAL FEET
C *** PER MINUTE OF FINISHED PAPER SHEET:
C *** ASPM = ((PPRO/1000.0) * (2000.0)/(PPMO/1000.0))/
C *** (TMO/12.0)
C *** CALCULATE MAXIMUM OPERATIONAL PAPER MACHINE SPEED IN LINEAL FEET
C *** PER MINUTE OF FINISHED PRODUCT:
C *** MPSP = ((PPRO/1000.0) * (2000.0)/(PMNO/1000.0))/
C *** (TMO/12.0)
C ***
C *** CALCULATE TOTAL WATER REMOVAL IN HEATED DRYER SECTION OF PAPER
C *** MACHINE, TONS OF WATER PER DAY:
C *** TMO = (TOTP/(1.0 - OSMC)) - (TOTP/(1.0 - PPMC))
C *** CALCULATE TONS OF EACH ADDITIVE REQUIRED PER DAY:

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114. TLM = PPRD * ALUM/2000.0
115. TACD = PPRD * ACID/2000.0
116. TSTC = PPRD * STYC/2000.0
117. TDFM = PPRD * DFORM/2000.0
118. TRSN = PPRD * ROBN/2000.0
119. TSLM = PPRD * SLIM/2000.0
120.
121.
122.
123. IF (NX.EG.1.OR.NX.EG.5.OR.NX.EG.6) GO TO 500
124. IF (NX.EG.7.OR.NX.EG.11.OR.NX.EG.12) GO TO 500
125. S0(1) = PPRD
126. S0(2) = PPMC = 100.0
127. S0(3) = PPRD/(1.0 - PPMC)
128. S0(4) = PPMC * PPRD/(1.0 - PPMC)
129. S0(5) = PPRD * DBRT
130. S0(6) = TOPY
131. S0(7) = TRMO
132. S0(8) = ASPO
133. S0(9) = WPPD
134. S0(10) = TWRD
135. S0(11) = DBMC = 100.0
136. S0(12) = PPMC = 100.0
137. S0(13) = PPRD * ALUM/2000.0
138. S0(14) = PPRD * ACID/2000.0
139. S0(15) = PPRD * STYC/2000.0
140. S0(16) = PPRD * DFORM/2000.0
141. S0(17) = PPRD * ROBN/2000.0
142. S0(18) = PPRD * SLIM/2000.0
143. S0(19) = PPRD * ADTV/2000.0 * (RCRT=RCYD) * (RPPR=PPD)
144. S0(20) = PPRD
145. S0(21) = RCRT
146. S0(22) = RPPR
147. S0(23) = DBRT
148. S0(24) = WPPD
149. S0(25) = TWRD
150. S0(26) = DBMC
151. S0(27) = PPMC
152. S0(28) = PPRD * ALUM/2000.0
153. S0(29) = PPRD * ACID/2000.0
154. S0(30) = PPRD * STYC/2000.0
155. S0(31) = PPRD * DFORM/2000.0
156. S0(32) = PPRD * ROBN/2000.0
157. S0(33) = PPRD * SLIM/2000.0
158. S0(34) = PPRD * ADTV/2000.0 * (RCRT=RCYD) * (RPPR=PPD)
159. S0(35) = PPRD
160. S0(36) = RCRT
161. S0(37) = RPPR
162. S0(38) = DBRT
163. S0(39) = WPPD
164. S0(40) = TWRD
165. S0(41) = DBMC
166. S0(42) = PPMC
167. S0(43) = PPRD * ALUM/2000.0
168. S0(44) = PPRD * ACID/2000.0
169. S0(45) = PPRD * STYC/2000.0
170. S0(46) = PPRD * DFORM/2000.0
171. S0(47) = PPRD * ROBN/2000.0
172. S0(48) = PPRD * SLIM/2000.0
173. S0(49) = PPRD * ADTV/2000.0 * (RCRT=RCYD) * (RPPR=PPD)
174. S0(50) = PPRD
175. S0(51) = RCRT
176. S0(52) = RPPR
177. S0(53) = DBRT
178. S0(54) = WPPD
179. S0(55) = TWRD
180. S0(56) = DBMC
181. S0(57) = PPMC
182. S0(58) = PPRD * ALUM/2000.0
183. S0(59) = PPRD * ACID/2000.0
184. S0(60) = PPRD * STYC/2000.0
185. S0(61) = PPRD * DFORM/2000.0
186. S0(62) = PPRD * ROBN/2000.0
187. S0(63) = PPRD * SLIM/2000.0
188. S0(64) = PPRD * ADTV/2000.0 * (RCRT=RCYD) * (RPPR=PPD)
189. S0(65) = PPRD
190. S0(66) = RCRT
191. S0(67) = RPPR
192. S0(68) = DBRT
193. S0(69) = WPPD
194. S0(70) = TWRD
195. S0(71) = DBMC
196. S0(72) = PPMC
197. S0(73) = PPRD * ALUM/2000.0
198. S0(74) = PPRD * ACID/2000.0
199. S0(75) = PPRD * STYC/2000.0
200. S0(76) = PPRD * DFORM/2000.0
201. S0(77) = PPRD * ROBN/2000.0
202. S0(78) = PPRD * SLIM/2000.0
203. S0(79) = PPRD * ADTV/2000.0 * (RCRT=RCYD) * (RPPR=PPD)
204. S0(80) = PPRD
205. S0(81) = RCRT
206. S0(82) = RPPR
207. S0(83) = DBRT
208. S0(84) = WPPD
209. S0(85) = TWRD
210. S0(86) = DBMC
211. S0(87) = PPMC
212. S0(88) = PPRD * ALUM/2000.0
213. S0(89) = PPRD * ACID/2000.0
214. S0(90) = PPRD * STYC/2000.0
215. S0(91) = PPRD * DFORM/2000.0
216. S0(92) = PPRD * ROBN/2000.0
217. S0(93) = PPRD * SLIM/2000.0
218. S0(94) = PPRD * ADTV/2000.0 * (RCRT=RCYD) * (RPPR=PPD)
219. S0(95) = PPRD
220. S0(96) = RCRT
221. S0(97) = RPPR
222. S0(98) = DBRT
223. S0(99) = WPPD
224. S0(100) = TWRD
225. S0(101) = DBMC
226. S0(102) = PPMC
227. S0(103) = PPRD * ALUM/2000.0
228. S0(104) = PPRD * ACID/2000.0
229. S0(105) = PPRD * STYC/2000.0
230. S0(106) = PPRD * DFORM/2000.0
231. S0(107) = PPRD * ROBN/2000.0
232. S0(108) = PPRD * SLIM/2000.0
233. S0(109) = PPRD * ADTV/2000.0 * (RCRT=RCYD) * (RPPR=PPD)
234. S0(110) = PPRD
235. S0(111) = RCRT
236. S0(112) = RPPR
237. S0(113) = DBRT
238. S0(114) = WPPD
239. S0(115) = TWRD
240. S0(116) = DBMC
241. S0(117) = PPMC
242. S0(118) = PPRD * ALUM/2000.0
243. S0(119) = PPRD * ACID/2000.0
244. S0(120) = PPRD * STYC/2000.0
245. S0(121) = PPRD * DFORM/2000.0
246. S0(122) = PPRD * ROBN/2000.0
247. S0(123) = PPRD * SLIM/2000.0
248. S0(124) = PPRD * ADTV/2000.0 * (RCRT=RCYD) * (RPPR=PPD)
249. S0(125) = PPRD
250. S0(126) = RCRT
251. S0(127) = RPPR
252. S0(128) = DBRT
253. S0(129) = WPPD
254. S0(130) = TWRD
255. S0(131) = DBMC
256. S0(132) = PPMC
257. S0(133) = PPRD * ALUM/2000.0
258. S0(134) = PPRD * ACID/2000.0
259. S0(135) = PPRD * STYC/2000.0
260. S0(136) = PPRD * DFORM/2000.0
261. S0(137) = PPRD * ROBN/2000.0
262. S0(138) = PPRD * SLIM/2000.0
263. S0(139) = PPRD * ADTV/2000.0 * (RCRT=RCYD) * (RPPR=PPD)
264. S0(140) = PPRD
265. S0(141) = RCRT
266. S0(142) = RPPR
267. S0(143) = DBRT
268. S0(144) = WPPD
269. S0(145) = TWRD
270. S0(146) = DBMC
271. S0(147) = PPMC
272. S0(148) = PPRD * ALUM/2000.0
273. S0(149) = PPRD * ACID/2000.0
274. S0(150) = PPRD * STYC/2000.0
275. S0(151) = PPRD * DFORM/2000.0
276. S0(152) = PPRD * ROBN/2000.0
277. S0(153) = PPRD * SLIM/2000.0
278. S0(154) = PPRD * ADTV/2000.0 * (RCRT=RCYD) * (RPPR=PPD)
279. S0(155) = PPRD
280. S0(156) = RCRT
281. S0(157) = RPPR
282. S0(158) = DBRT
283. S0(159) = WPPD
284. S0(160) = TWRD
285. S0(161) = DBMC
286. S0(162) = PPMC
287. S0(163) = PPRD * ALUM/2000.0
288. S0(164) = PPRD * ACID/2000.0
289. S0(165) = PPRD * STYC/2000.0
290. S0(166) = PPRD * DFORM/2000.0
291. S0(167) = PPRD * ROBN/2000.0
292. S0(168) = PPRD * SLIM/2000.0
293. S0(169) = PPRD * ADTV/2000.0 * (RCRT=RCYD) * (RPPR=PPD)
294. S0(170) = PPRD
295. S0(171) = RCRT
296. S0(172) = RPPR
297. S0(173) = DBRT
298. S0(174) = WPPD
299. S0(175) = TWRD
300. S0(176) = DBMC
301. S0(177) = PPMC
302. S0(178) = PPRD * ALUM/2000.0
303. S0(179) = PPRD * ACID/2000.0
304. S0(180) = PPRD * STYC/2000.0
305. S0(181) = PPRD * DFORM/2000.0
306. S0(182) = PPRD * ROBN/2000.0
307. S0(183) = PPRD * SLIM/2000.0
308. S0(184) = PPRD * ADTV/2000.0 * (RCRT=RCYD) * (RPPR
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661-672
673-684
685-696
697-708
709-720
721-732
733-744
745-756
757-768

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SUBJECTIVE REPORT

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CMPC	-	WEIGHT RATIO REMOVED AS BARK IN DEBARKING HARDWOOD ROUNDWOOD PULPWOOD, RATIO OF TOTAL DRY WEIGHT OF PURCHASED ROUNDWOOD, INCLUDING BARK.
CMCM	-	MOISTURE CONTENT OF HARDWOOD PURCHASED "CLEAN" CHIP PULPWOOD, DECIMAL RATIO OF WET WEIGHT, AVERAGE.
CMTC	-	FINES REMOVED IN SCREENING HARDWOOD PURCHASED "CLEAN" CHIPS AS A RATIO OF TOTAL DRY WEIGHT OF HARDWOOD PURCHASED "CLEAN" CHIPS.
CMCO	-	TOTAL WEIGHT PER CORD OF HARDWOOD ROUNDWOOD PULPWOOD, NET WEIGHT BASIS, POUNDS PER CORD INCLUDING BARK, AS PURCHASED.
CMFR	-	FINES REMOVED IN SCREENING HARDWOOD ROUNDWOOD CHIPS AS A RATIO OF TOTAL DRY WEIGHT OF HARDWOOD ROUNDWOOD CHIPS BEFORE SCREENING.
CMWC	-	AVERAGE MOISTURE CONTENT IN HARDWOOD ROUNDWOOD PULPWOOD, RATIO OF TOTAL WET WEIGHT OF PULPWOOD AS PURCHASED, INCLUDING BARK.
CMPC	-	HARDWOOD PURCHASED CHIPS (WHOLE-TREE AND "CLEAN") AS A RATIO OF TOTAL HARDWOOD CHIPS INTO DIGESTER, FRACTION OF TOTAL DRY WEIGHT OF HARDWOOD PURCHASED AND ROUNDWOOD CHIPS.
CMTC	-	HARDWOOD "WHOLE-TREE" CHIPS AS A RATIO OF TOTAL HARDWOOD PURCHASED CHIPS, RATIO OF TOTAL DRY WEIGHT OF HARDWOOD PURCHASED CHIPS.
CMTF	-	BARK AND FINES REMOVED IN SCREENING HARDWOOD "WHOLE-TREE" CHIPS AS A DECIMAL RATIO OF TOTAL DRY WEIGHT OF HARDWOOD "WHOLE-TREE" CHIPS.
CMTH	-	MOISTURE CONTENT OF HARDWOOD PURCHASED "WHOLE-TREE" CHIPS, DECIMAL RATIO OF WET WEIGHT, AVERAGE.
CMPC	-	PRICE OR VALUE OF HARDWOOD PURCHASED "CLEAN" CHIPS, \$ PER TON AS PURCHASED, AVERAGE.
CMWH	-	PURCHASE PRICE F.O.B. MILL FOR HARDWOOD ROUNDWOOD, \$ PER CORD, AVERAGE.
CMWC	-	PURCHASE PRICE, FOB MILL, FOR HARDWOOD "WHOLE-TREE" CHIPS, \$ PER TON AS PURCHASED, AVERAGE.
CMWD	-	QUANTITY OF SCREENED PULPWOOD CHIPS REQUIRED, DRY TONS PER DAY INTO DIGESTER, AVERAGE TOTAL QUANTITY.
CMPC	-	PRICE OR VALUE OF SOFTWOOD PURCHASED "CLEAN" CHIPS, \$ PER TON AS PURCHASED, AVERAGE.
CMWH	-	PURCHASE PRICE F.O.B. MILL FOR SOFTWOOD ROUNDWOOD, \$ PER CORD, AVERAGE.
CMWC	-	PURCHASE PRICE F.O.B. MILL FOR SOFTWOOD "WHOLE-TREE" CHIPS, \$ PER TON AS PURCHASED, AVERAGE.
CMPC	-	WEIGHT RATIO REMOVED AS BARK IN DEBARKING SOFTWOOD ROUNDWOOD PULPWOOD, RATIO OF TOTAL DRY WEIGHT OF PURCHASED ROUNDWOOD, INCLUDING BARK.
CMCM	-	MOISTURE CONTENT OF SOFTWOOD PURCHASED "CLEAN" CHIP PULPWOOD, DECIMAL RATIO OF WET WEIGHT, AVERAGE.
CMTC	-	SOFTWOOD RATIO OF TOTAL PULPWOOD CHIPS INTO DIGESTER, DECIMAL RATIO OF TOTAL DRY WEIGHT OF CHIPS.
CMTC	-	FINES REMOVED IN SCREENING SOFTWOOD PURCHASED "CLEAN" CHIPS AS A RATIO OF TOTAL DRY WEIGHT OF SOFTWOOD PURCHASED "CLEAN" CHIPS.

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C *** PURCHASED "CLEAN" CHIPS.
C *** SHCD = TOTAL WEIGHT PER CORD OF SOFTWOOD ROUNDWOOD PULPMOOD, METRIC
C *** WEIGHT BASIS, POUNDS PER CORD INCLUDING BARK, AS PURCHASED
C *** SHFR = FINES REMOVED IN SCREENING SOFTWOOD ROUNDWOOD CHIPS (TO
C *** WOOD FUEL) AS A RATIO OF TOTAL DRY WEIGHT OF SOFTWOOD
C *** ROUNDWOOD CHIPS BEFORE SCREENING.
C *** SHMC = AVERAGE MOISTURE CONTENT IN SOFTWOOD ROUNDWOOD PULPMOOD,
C *** RATIO OF TOTAL WET WEIGHT OF PULPMOOD AS PURCHASED,
C *** INCLUDING BARK.
C *** SHPC = SOFTWOOD PURCHASED CHIPS (WHOLE-TREE AND "CLEAN") AS A
C *** RATIO OF TOTAL SOFTWOOD INTO DIGESTER, FRACTION OF
C *** TOTAL DRY WEIGHT OF SOFTWOOD PURCHASED AND ROUNDWOOD
C *** CHIPS.
C *** SHTC = SOFTWOOD WHOLE-TREE CHIPS AS A RATIO OF TOTAL SOFTWOOD
C *** PURCHASED CHIPS, RATIO OF TOTAL DRY WEIGHT OF SOFTWOOD
C *** PURCHASED CHIPS.
C *** SHTF = BARK AND FINES REMOVED IN SCREENING SOFTWOOD WHOLE-TREE
C *** CHIPS AS A DECIMAL RATIO OF TOTAL DRY WEIGHT OF
C *** SOFTWOOD WHOLE-TREE CHIPS.
C *** SHTM = MOISTURE CONTENT OF SOFTWOOD PURCHASED WHOLE-TREE CHIPS,
C *** DECIMAL RATIO OF WET WEIGHT, AVERAGE.
C *** READ STATEMENTS:
C *** READ (5,10)HPC,MCHW,MTCF,MHCD,MHFR,MHMC,MHPC,MHWC,MHTE,MHMT,
C *** * HPC,PCHW,PCHC,PCPC,PCPR,PSMC,SPBC,SCMW,SPCD,STCF,
C *** * SHCD,SHFR,SHMC,SHPC,SHTC,SHTF,SHTM
C *** 10 FORMAT (//27(F20.0//))
C *** CALCULATIONS:
C *** CALCULATE DRY TONS PER DAY OF SOFTWOOD CHIPS INTO DIGESTER:
C *** SPWD = SPWD * SFMO
C *** CALCULATE DRY TONS PER DAY OF HARDWOOD CHIPS INTO DIGESTER:
C *** HPWD = HPWD * (1.0 - SFHW)
C *** CALCULATE DRY TONS PER DAY OF SOFTWOOD ROUNDWOOD CHIPS INTO
C *** DIGESTER:
C *** SPWC = SPWD * (1.0 - SHPC)
C *** CALCULATE DRY TONS PER DAY OF HARDWOOD CHIPS INTO
C *** DIGESTER:
C *** HPWC = HPWD * (1.0 - HPC)
C *** CALCULATE DRY TONS PER DAY OF SOFTWOOD FINES REMOVED IN SCREENING
C *** SOFTWOOD ROUNDWOOD PULPMOOD CHIPS (FINES GO TO POWER BOILER FUEL
C *** STORAGE AREA):
C *** SFRF = (SPRW/(1.0 - SHFR)) * SHFR
C *** CALCULATE DRY TONS PER DAY OF HARDWOOD FINES REMOVED IN SCREENING
C *** HARDWOOD ROUNDWOOD PULPMOOD CHIPS (FINES GO TO POWER BOILER FUEL
C *** STORAGE AREA):
C *** HFRF = (HRPW/(1.0 - HPCR)) * MHFR
C *** CALCULATE DRY TONS PER DAY OF SOFTWOOD BARK REMOVED FROM SOFTWOOD
C *** ROUNDWOOD (TO POWER BOILER FUEL STORAGE AREA):
C *** SBRA = ((SRPW * SHFR)/(1.0 - SHPC)) * SHPC
C *** CALCULATE DRY TONS PER DAY OF HARDWOOD BARK REMOVED FROM HARDWOOD
C *** ROUNDWOOD (TO POWER BOILER FUEL STORAGE AREA):
C *** HBRA = ((HRPW * MHFR)/(1.0 - HPCR)) * HPCR
C *** CALCULATE REQUIRED CORDS PER DAY OF SOFTWOOD ROUNDWOOD PULPMOOD:
C *** COSW = ((SRPW * SHFR * SBRA)/(1.0 - SHMC))/(SHCD/2000.0)
C *** CALCULATE REQUIRED CORDS PER DAY OF HARDWOOD ROUNDWOOD PULPMOOD:
C *** COMH = ((HRPW * MHFR * HBRA)/(1.0 - MHMC))/(MHCD/2000.0)
C *** CALCULATE DRY TONS PER DAY OF SCREENED SOFTWOOD PURCHASED CHIPS
C *** INTO DIGESTER:
C *** SPCH = SPWD * SHPC
C *** CALCULATE DRY TONS PER DAY OF SCREENED HARDWOOD PURCHASED CHIPS
C *** INTO DIGESTER:
C *** HPCH = HPWD * HPC
C *** CALCULATE DRY TONS PER DAY OF SOFTWOOD FINES, INCLUDING FINES
C *** FROM WHOLE-TREE CHIPS AND 'CLEAN' CHIPS SCREENING (FINES TO
C *** POWER BOILER FUEL STORAGE AREA):
C *** SHCF = ((SPCW * SHTC)/(1.0 - SHTF)) * SHTF
C *** SPFC = ((SPCW * (1.0 - SHTC))/(1.0 - STCF)) * STCF
C *** CALCULATE DRY TONS PER DAY OF HARDWOOD FINES, INCLUDING FINES
C *** FROM WHOLE-TREE CHIP AND 'CLEAN' CHIP SCREENING (FINES TO POWER
C *** BOILER FUEL STORAGE AREA):
C *** MHCF = ((MPCH * MTCF)/(1.0 - MHTF)) * MHTF
C *** MPFC = ((MPCH * (1.0 - MTCF))/(1.0 - MTFC)) * MTFC
C *** CALCULATE DRY TONS PURCHASED PER DAY OF "CLEAN" SOFTWOOD CHIPS,
C *** INCLUDING FINES:
C *** SPCC = (SPCW * (1.0 - SHTC)) * SHCF

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25. C *** EXPRESSED IN SODIUM OXIDE WEIGHT EQUIVALENTS, AND IN
26. C *** WHICH THE SODIUM HYDROXIDE CONTENT OF GREEN LIQUOR HAS
27. C *** BEEN SUBTRACTED FROM THE WHITE LIQUOR CONTENT (STANDARD
28. C *** TAPPI DEFINITION).
29. C *** CHMO - CONSISTENCY OF THE FILTERED LIME MUD ENTERING THE LIME
30. C *** KILN, DRY WEIGHT OF LIME MUD SOLIDS RATIO OF TOTAL
31. C *** WEIGHT OF FILTERED LIME MUD.
32. C *** EPRF - AVERAGE COMBUSTION HEATING EFFICIENCY OF KILN FUEL,
33. C *** RATIO OF HIGHER HEATING VALUE OF FUEL WHICH IS NOT
34. C *** LOST IN COMBUSTION GASES AND EXCESS AIR EXITING
35. C *** THE KILN.
36. C *** FLWR - LIME MUD RECYCLING RATIO, WEIGHT RATIO OF TOTAL LIME
37. C *** MUD ENTERING LIME KILN WHICH IS RECYCLED TO THE
38. C *** MUD WASHER, REPRESENTING UNCALCINED MATERIAL WHICH
39. C *** IS CAPTURED IN THE LIME KILN FLUE GAS SCRUBBER AND
40. C *** EMISSIONS SEPARATOR.
41. C *** MHKF - AVERAGE HIGHER HEATING VALUE OF KILN FUEL IN MILLIONS OF
42. C *** B.T.U. PER UNIT OF FUEL (E.G., PER MCF OF GAS, FOR
43. C *** EXAMPLE).
44. C *** MRRB - EFFECTIVE HEAT RECOVERY RATIO OF RECOVERY BOILER, DECIMAL
45. C *** RATIO OF GROSS HEAT ENERGY VALUE OF BLACK LIQUOR
46. C *** SOLIDS THAT ARE RECOVERED AS STEAM HEAT ENERGY (ADJUSTED
47. C *** FOR TOTAL HEAT INPUTS TO FURNACE AND HEAT OF REACTION
48. C *** CORRECTION) AS WELL AS FOR COMBUSTION HEAT LOSSES; NOT TO
49. C *** BE CONFUSED WITH "COMBUSTION HEAT RECOVERY EFFICIENCY"
50. C *** OF RECOVERY BOILER).
51. C *** MVL - GROSS HEAT ENERGY VALUE (HEATING VALUE) OF BLACK LIQUOR
52. C *** SOLIDS, B.T.U. PER DRY POUND.
53. C *** PLMU - PURCHASED LIME MAKE-UP, AVERAGE WEIGHT RATIO OF TOTAL
54. C *** LIME TO SLAKER WHICH IS PURCHASED OR "MAKE-UP" LIME.
55. C *** PPRF - AVERAGE PURCHASE PRICE OF KILN FUEL IN DOLLARS PER UNIT OF
56. C *** FUEL.
57. C *** PPLM - PURCHASE PRICE OF PURCHASED LIME IN DOLLARS PER TON,
58. C *** F.O.B. MILL.
59. C *** SVSC - SALES VALUE OF SURPLUS SALTCAKE GENERATED IN CHEMICAL
60. C *** RECOVERY AND DESULFURIZATION AREAS, $/DRY TON OF SURPLUS
61. C *** SALTCAKE, F.O.B. MILL.
62. C *** SSNL - SODIUM SULFATE RATIO OF TOTAL ALKALI IN WHITE LIQUOR,
63. C *** (ONE-HALF) WEIGHT RATIO IN SODIUM OXIDE EQUIVALENTS.
64. C *** TBL - TOTAL BLACK LIQUOR SOLIDS TO SALT CAKE MIX TANKS AND
65. C *** RECOVERY BOILER AREA, DRY TONS PER DAY OF BLACK LIQUOR
66. C *** SOLIDS.
67. C *** TODA - TONS PER DAY OF ACTIVE ALKALI IN SODIUM OXIDE WEIGHT
68. C *** EQUIVALENT, IN WHITE LIQUOR TO DIGESTER, FROM WHITE
69. C *** LIQUOR CLARIFIER.
70. C *** TREG - TEMPERATURE OF KILN EXIT GASES IN DEGREES FAHRENHEIT, AVE.
71. C *** THPD - AVERAGE TEMPERATURE OF KILN PRODUCT SOLIDS EXITING KILN,
72. C *** IN DEGREES FAHRENHEIT.
73. C *** READ STATEMENTS!
74. C *** READ (5,10)ACTV,AVLM,CAUS,CHMO,EPRF,FLWR,MHMF,MRRB,MVL,PLMU,PPKF,
75. C *** PPLM,SVSC,SSNL,TREG,TRPD
76. C *** FORMAT (/16(P20.0//))
77. C ***
78. C *** CALCULATIONS:
79. C ***
80. C *** CALCULATE HEAT ENERGY TO STEAM IN RECOVERY BOILER, MILLIONS OF
81. C *** B.T.U. PER DAY:
82. C *** MRRB = TBL * (0.002) * MVL * MRRB
83. C ***
84. C *** CALCULATE THE WEIGHT EQUIVALENT OF THE TOTAL ALKALI (TOTAL SODIUM
85. C *** COMPOUNDS) IN WHITE LIQUOR, IN SODIUM OXIDE WEIGHT EQUIVALENT,
86. C *** TONS PER DAY:
87. C *** TALK = TODACTV
88. C ***
89. C *** CALCULATE THE WEIGHT EQUIVALENT OF SODIUM SULFATE IN WHITE
90. C *** LIQUOR, IN SODIUM OXIDE WEIGHT EQUIVALENT, TONS PER DAY:
91. C *** SSNL = TALK * SSNL
92. C ***
93. C *** CALCULATE THE WEIGHT EQUIVALENT OF SODIUM CARBONATE IN WHITE
94. C *** LIQUOR, IN SODIUM OXIDE WEIGHT EQUIVALENT, TONS PER DAY:
95. C *** SOCA = TALK * (TODA * SOSL)
96. C ***
97. C *** CALCULATE THE WEIGHT EQUIVALENT OF SODIUM HYDROXIDE PRODUCED IN
98. C *** CAUSTICIZING REACTION, IN SODIUM OXIDE WEIGHT EQUIVALENT,
99. C *** CORRECTED FOR SODIUM HYDROXIDE PRESENT IN GREEN LIQUOR, BASED ON
100. C *** TAPPI DEFINITION OF CAUSTICIZING EFFICIENCY, TONS PER DAY:
101. C *** SODM = (CAUS * SOCA)/(1.0 - CAUS)
102. C ***
103. C *** CALCULATE THEORETICAL WEIGHT OF CALCIUM OXIDE FOR CAUSTICIZING
104. C *** REACTION, TONS PER DAY:
105. C *** CROX = SODM * (56.0/62.0)

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103. C *** CALCULATE QUANTITY OF PURCHASED LIME REQUIRED, TONS PER DAY:
104. C *** ALPO = (CROX * PLMU)/(AVLM)
105. C ***
106. C *** CALCULATE TOTAL WEIGHT OF LIME PRODUCED IN LIME KILN TO SLAKER,
107. C *** IN TONS PER DAY:
108. C *** TMLP = (CROX/AVLM) - PLPO
109. C ***
110. C *** CALCULATE ACTUAL WEIGHT OF LIME CONSUMED IN SLAKING & CAUSTIC.
111. C *** CROX = CROX/AVLM
112. C ***
113. C *** CALCULATE WEIGHT OF INERT MATERIAL IN LIME FROM LIME KILN TO
114. C *** SLAKER, TONS PER DAY:
115. C *** TMLR = TMLP * (1.0 - AVLW)
116. C ***
117. C *** CALCULATE THEORETICAL DRY WEIGHT OF LIME MUD TO LIME KILN, TONS
118. C *** PER DAY:
119. C *** WLM = (TMLP + TMLR) * (100.0/56.0) * MINR
120. C ***
121. C *** CALCULATE ACTUAL DRY WEIGHT OF LIME MUD TO LIME KILN AFTER
122. C *** CORRECTING FOR PARTICULATE EMISSIONS AND RECYCLED FRACTION (TO
123. C *** MUD WASHER), TONS PER DAY OF LIME MUD:
124. C *** WLM = WLM/(1.0 - FLWR)
125. C ***
126. C *** CALCULATE WEIGHT OF WATER ENTERING LIME KILN WITH FILTERED LIME
127. C *** MUD, TONS PER DAY:
128. C *** WMP = (WLM/CHMO) * (1.0 - CHMO)
129. C ***
130. C *** CALCULATE HEAT ENERGY REQUIREMENTS FOR LIME KILN IN MILLIONS OF
131. C *** B.T.U. PER DAY (ASSUMING AMBIENT TEMP. OF 70 DEG. F.):
132. C *** (A.) ENERGY REQUIRED TO EVAPORATE WATER IN LIME MUD ENTERING
133. C *** KILN:
134. C *** WTEM = WLM * (0.002) * (970.0 * (212.0 - 70.0) *
135. C *** (0.56) (TREG - 212.0))
136. C ***
137. C *** (B.) ENERGY INTO KILN PRODUCT, ASSUMING A SPECIFIC HEAT OF
138. C *** 0.25 B.T.U. PER POUND OF KILN PRODUCT PER DEGREE F. ABOVE
139. C *** AMBIENT TEMPERATURE:
140. C *** PLEN = TMLP * (0.002) * (TRPD - 70.0) * 0.25
141. C ***
142. C *** (C.) ENERGY REQUIRED FOR DISSOCIATION OF CALCIUM CARBONATE IN
143. C *** LIME KILN, ASSUMING A HEAT OF DISSOCIATION OF 1,390 B.T.U. PER
144. C *** POUND OF ACTIVE CALCIUM OXIDE IN LIME KILN PRODUCT:
145. C *** MDEN = (TMLP * AVLW) * (0.002) * (1390.0)
146. C ***
147. C *** (D.) ENERGY INTO CARBON DIOXIDE PRODUCED IN DISSOCIATION
148. C *** REACTION, ASSUMING A SPECIFIC HEAT OF 0.25 B.T.U. PER
149. C *** POUND OF CARBON DIOXIDE GAS PER DEGREE F. ABOVE AMBIENT
150. C *** TEMPERATURE:
151. C *** CDEN = (TMLP * AVLW) * (0.0/56.0) * (0.002) * (0.25) *
152. C *** (TREG - 70.0)
153. C ***
154. C *** (E.) CALCULATE ENERGY INTO RECYCLED LIME MUD, "DUST" CAPTURED
155. C *** IN SCRUBBER AND SEPARATORS, ASSUMING A SPECIFIC HEAT OF 0.25
156. C *** B.T.U. PER POUND OF DUST, PER DEGREE F. ABOVE AMBIENT:
157. C *** EMEN = (WLM * FLWR) * (0.002) * (TREG - 70.0) * 0.25
158. C ***
159. C *** (F.) CALCULATE TOTAL HEAT ENERGY REQUIREMENTS INCLUDING A
160. C *** 15.0 PERCENT FACTOR FOR THERMAL RADIATION HEAT LOSSES:
161. C *** TSEN = (WTEM + PLEN + MDEN + CDEN + EMEN) * 1.15
162. C ***
163. C *** CALCULATE GROSS ENERGY INPUT REQUIREMENTS IN KILN FUEL,
164. C *** MILLION B.T.U. PER DAY:
165. C *** GREN = TSEN/EPHF
166. C ***
167. C *** CALCULATE UNITS OF KILN FUEL REQUIRED PER DAY:
168. C *** TRPF = GREN/MHMF
169. C ***
170. C *** END

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***** ELEC *****

C *** THIS IS THE SUBROUTINE THAT CALCULATES ELECTRIC POWER

C *** REQUIREMENTS

C ***

C *** SUBROUTINE ELEC

C ***

C *** COMMON/ALL/CAOX,CONH,COSM,COGN,CPRC,CBDS,MRRK,MCCM,MHCH,MRRF,

C *** MRRB,MZ,PCO,PCALM,

C *** PCAS,PCOR,PPOR,PERG,PETC,PHPC,PHMC,PSHC,PSMC,PSNR,PLRO,PPAP,

C *** PPAT,PPLM,PPRO,PPSC,PPHO,PROD,PSNM,PSCR,PSLM,PSPC,PSRN,PSYC,

C *** PHCH,PHTR,PGOL,GMOD,RCRT,RPPT,

C *** SBRK,SCLS,SHOM,SCCH,SCCH,SCCH,SCCH,SCCH,SCCH,SCCH,SCCH,SCCH,

C *** SVSC,TACO,TALM,TBLT,TDFA,TEED,TEFC,TNFR,TNRR,TPBV,TRPD,

C *** TRSH,TSLM,TATC,TMLP,TMLV,TMRD,TUTC,MPRC,MRCN,MREV

C *** DIMENSION MP(16)

C *** THIS IS THE LIST OF INPUTS:

C ***

C *** (TOTAL CONNECTED HORSEPOWER OF MACHINES AND EQUIPMENT BY MILL

C *** AREA)

C ***

C ***

C ***

C ***

C ***

C ***

C ***

C ***


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102. C *** CONDENSATE).
103. C *** HIGH PRESSURE STEAM DEMAND OF PAPER MACHINE THERMO-
104. C *** COMPRESSORS FOR DRYER DRAINAGE, POUNDS OF STEAM PER DRY
105. C *** TON OF PAPER OR PAPERBOARD PRODUCT.
106. C
107. C *** AVERAGE MEDIUM PRESSURE PROCESS STEAM DEMANDS:
108. C
109. C *** SHAM - MEDIUM PRESSURE STEAM DEMAND FOR AIR HEATER IN RECOVERY
110. C *** BOILER AREA, POUNDS OF STEAM PER TON OF BLACK LIQUOR
111. C *** SOLIDS TO RECOVERY BOILER.
112. C *** SHAS - MEDIUM PRESSURE STEAM DEMAND FOR AIR SUPPLY AREA, POUNDS
113. C *** OF STEAM PER DRY TON OF PULP PRODUCED.
114. C *** SHBL - MEDIUM PRESSURE STEAM DEMAND FOR BLACK LIQUOR GUNS IN
115. C *** RECOVERY BOILER FURNACE, POUNDS OF STEAM PER TON OF BLACK
116. C *** LIQUOR SOLIDS TO RECOVERY FURNACE.
117. C *** SHDH - MEDIUM PRESSURE STEAM DEMAND FOR DIGESTER LIQUOR HEATER,
118. C *** POUNDS OF STEAM PER THOUSAND GALLONS OF WHITE LIQUOR TO
119. C *** DIGESTER.
120. C *** SHFN - MEDIUM PRESSURE STEAM DEMAND FOR POWER BOILER FEEDWATER
121. C *** HEATERS, POUNDS OF STEAM PER POUND OF FEEDWATER TO POWER
122. C *** BOILER.
123. C *** SNEC - MEDIUM PRESSURE STEAM DEMAND FOR EMISSIONS CONTROL
124. C *** ELECTROSTATIC PRECIPITATORS) IN RECOVERY BOILER AREA,
125. C *** POUNDS OF STEAM PER TON OF BLACK LIQUOR SOLIDS TO
126. C *** RECOVERY FURNACE.
127. C *** SHJE - MEDIUM PRESSURE STEAM FOR STEAM JETS IN EVAPORATORS,
128. C *** POUNDS OF STEAM PER TON OF BLACK LIQUOR SOLIDS INTO
129. C *** EVAPORATORS.
130. C *** SHLM - MEDIUM PRESSURE STEAM DEMAND FOR SECONDARY BLACK LIQUOR
131. C *** HEATER IN RECOVERY BOILER AREA, POUNDS OF STEAM PER TON
132. C *** OF BLACK LIQUOR SOLIDS TO RECOVERY BOILER.
133. C *** SHMD - MEDIUM PRESSURE PROCESS STEAM MISCELLANEOUS DEMAND VOLUME,
134. C *** POUNDS OF STEAM PER TON OF PRODUCT.
135. C *** SHPB - MEDIUM PRESSURE STEAM DEMAND FOR POWER BOILER AREA, AIR
136. C *** HEATERS, EMISSIONS CONTROL, AND MISCELLANEOUS POUNDS OF
137. C *** STEAM PER POUND OF STEAM PRODUCED IN POWER BOILERS.
138. C *** SHPD - MEDIUM PRESSURE STEAM DEMAND FOR PAPER MACHINE DRYERS,
139. C *** POUNDS OF STEAM PER POUND OF WATER REMOVED IN HEATED
140. C *** DRYER SECTION OF PAPER MACHINE.
141. C *** SHSL - LOSSES FROM MEDIUM PRESSURE PROCESS STEAM SYSTEM (RATIO
142. C *** OF TOTAL MEDIUM PRESSURE STEAM NOT RETURNED IN
143. C *** CONDENSATE).
144. C *** SHST - MEDIUM PRESSURE STEAM DEMAND FOR SMELT DISSOLVING TANK IN
145. C *** RECOVERY AREA, POUNDS OF STEAM PER TON OF BLACK LIQUOR
146. C *** SOLIDS TO RECOVERY BOILER.
147. C
148. C *** AVERAGE LOW PRESSURE PROCESS STEAM DEMANDS:
149. C
150. C *** SLAM - LOW PRESSURE STEAM DEMAND FOR AIR HEATER IN RECOVERY
151. C *** BOILER AREA, POUNDS OF STEAM PER TON OF BLACK LIQUOR
152. C *** SOLIDS TO RECOVERY.
153. C *** SLCN - LOW PRESSURE STEAM DEMAND FOR BLACK LIQUOR CONCENTRATORS,
154. C *** POUNDS OF STEAM PER POUND OF WATER REMOVED IN BLACK
155. C *** LIQUOR CONCENTRATORS.
156. C *** SLDA - LOW PRESSURE STEAM DEMAND FOR DEAERATOR, POUNDS OF STEAM
157. C *** PER POUND OF TOTAL FEEDWATER.
158. C *** SLOG - LOW PRESSURE STEAM DEMAND FOR DIGESTER STEAMING VESSEL,
159. C *** POUNDS OF STEAM PER TON OF CHIPS TO DIGESTER.
160. C *** SLEV - LOW PRESSURE STEAM DEMAND FOR BLACK LIQUOR EVAPORATORS,
161. C *** POUNDS OF STEAM PER POUND OF WATER REMOVED FROM BLACK
162. C *** LIQUOR IN EVAPORATORS.
163. C *** SLMD - LOW PRESSURE MISCELLANEOUS STEAM DEMAND, POUNDS OF STEAM
164. C *** PER DRY TON OF PAPER OR PAPERBOARD PRODUCT.
165. C *** SLPA - LOW PRESSURE STEAM DEMAND FOR POWER BOILER AREA, AIR
166. C *** HEATERS, EMISSIONS CONTROL, MISCELLANEOUS, POUNDS PER
167. C *** POUND OF STEAM PRODUCED IN POWER BOILER.
168. C *** SLPM - LOW PRESSURE STEAM DEMAND FOR PAPER MACHINE AUXILIARY
169. C *** EQUIPMENT AND MISCELLANEOUS PURPOSES, POUNDS OF STEAM PER
170. C *** DRY TON OF PRODUCT.
171. C *** SLPS - LOW PRESSURE STEAM DEMAND FOR HEATING GREEN LIQUOR TO
172. C *** SLAKER IN RECAUSTICIZING AREA, POUNDS OF STEAM PER TON OF
173. C *** BLACK LIQUOR SOLIDS TO RECOVERY AREA.
174. C *** SLSE - LOW PRESSURE STEAM DEMAND FOR SULFUR EMISSIONS ODOR
175. C *** CONTROL, COLLECTION SYSTEM, POUNDS PER DRY TON OF PULP
176. C *** PRODUCED.
177. C *** BLSL - LOSSES FROM LOW PRESSURE PROCESS STEAM SYSTEM (RATIO OF
178. C *** TOTAL LOW PRESSURE STEAM VOLUME THAT IS NOT RETURNED IN
179. C *** CONDENSATE TO DEAERATOR).
180. C
181. C *** READ STATEMENTS:
182. C
183. C *** DIMENSION O(40,5),OP(20,3)
184. C *** READ(5,11) BFFC,CNLS,FHNE,MCCN,MCMW,MHPP,MLPP,MHPP,MHSH,MTMS,PKMW,
185. C *** SHLS,SSSB,SVSE,TGEF,MPAM,MHPP,MHMD,MHPP,MHPP,MHPP,MHPP,MHPP,
186. C *** SHAM,SHAS,SHBL,SHDH,SHFN,SHJE,SHLM,SHMD,SHPB,SHPD,SHSL,
187. C *** SHST,SHSLAM,SLCN,SLDA,SLOG,SLEV,SLWD,SLWP,SLPS,SLRS,
188. C *** SLSE,SLSL
189. C *** FORMAT (//20F20.0//)
190. C *** CALCULATIONS:
191. C *** SET INITIAL FEEDWATER ENTHALPY TO ZERO:
192. C *** WFW = 0.0
193. C *** CALCULATE INITIAL ESTIMATE OF RECOVERY BOILER STEAM OUTPUT,
194. C *** POUNDS OF SUPERHEATED STEAM/DAY:
195. C *** SORR = (MSRB + 100000.0)/(MSHP - MFWB)
196. C *** CALCULATE INITIAL ESTIMATE OF NET BOILER STEAM DEMANDS, POUNDS OF
197. C *** SUPERHEATED STEAM/DAY:
198. C *** -- (HIGH PRESSURE PROCESS STEAM DEMANDS)
199. C *** MPD = (MPPM + PPRD) + (MPTC + PPRD) + (MPAM + TBL) +
200. C *** (MPMD + PPRD)
201. C *** -- (MEDIUM PRESSURE PROCESS STEAM DEMANDS, APPROX.)
202. C *** SHSD = (SMPD + THRD + 2000.0) + (SMJE + (TELS + SORR)) +
203. C *** (SMOH + TBLV) +
204. C *** (TBL + SNEC + SHAM + SHST + SHLM + SHML) +
205. C *** (SMAS + PROD) +
206. C *** (SMHD + PROD) +
207. C *** (MPPM + PPRD) -
208. C *** (MPSD - (MPPM + PPRD))
209. C *** GMSD = SHSD + (MPPM + PPRD) + ((MPSD - (MPPM + PPRD)) * MTMS)
210. C *** SHLP = 0.0
211. C *** IF (SHSD .LT. 0.0) SHLP = -SHSD
212. C *** IF (SHSD .LT. 0.0) SHSD = 0.0
213. C *** GMSD = GMSD - SHLP
214. C *** -- (LOW PRESSURE STEAM DEMANDS, APPROX.)
215. C *** SLSD = (PPRD + (SLPM + SLMD)) +
216. C *** ((TBL + (SLRS + SLAM)) +
217. C *** ((SLEV + MREV) + (SLCN + MRCN)) + 2000.0) +
218. C *** (SLGC + PROD) +
219. C *** (SLSE + PROD) +
220. C *** (SHLS + GMSD) - SHLP
221. C *** CALCULATE INITIAL ESTIMATE OF POWER BOILER STEAM OUTPUT, POUNDS
222. C *** OF SUPERHEATED STEAM/DAY:
223. C *** SORP = (MPSD + SHSD + SLSD - SORR + (SSSB + SORR)) +
224. C *** (SLDA + SORR + (1.0 + BFFC))/(1.0 - SSSB - (MPPM +
225. C *** SHFW + SLDA) + (1.0 + BFFC)) - (MPPB + SHPB + SLPB))
226. C *** FOLLOW ITERATIVE PROCEDURE TO DETERMINE THE STEAM ENERGY BALANCE
227. C *** (ALGORITHM ITERATES UNTIL EQUILIBRIUM ENTHALPY OF FEEDWATER TO
228. C *** RECOVERY BOILER IS OBTAINED):
229. C *** CONTINUE
230. C *** CALCULATE TOTAL STEAM AND CONDENSATE LOSSES FROM STEAM SYSTEM,
231. C *** EQUIVALENT TO MAKE-UP WATER REQUIREMENTS, POUNDS LOST/DAY:
232. C *** TSL = (SSSB + (SORP + SORR)) +
233. C *** (0.7 + BFFC + (SORP + SORR)) +
234. C *** (MPSL + MPSD) +
235. C *** (SHSL + GMSD) +
236. C *** (SLSL + (SLSD + (SHLS + GMSD))) +
237. C *** (CNLS + (SOPB + SORR) + (1.0 + BFFC))
238. C *** CALCULATE QUANTITY OF CONDENSATE TO DEAERATOR, POUNDS/DAY (PBFM
239. C *** IS FEEDWATER TO POWER BOILER):
240. C *** PBFM = (SOPB + (1.0 + BFFC))
241. C *** CNOA = (SOPB + SORR) + (1.0 + BFFC) - TSL -
242. C *** ((SHFW + MREV) + PBFM) -
243. C *** (SLDA + (SOPB + SORR) + (1.0 + BFFC))
244. C *** CALCULATE ENTHALPY OF FEEDWATER TO RECOVERY BOILER AND POWER
245. C *** BOILER FEEDWATER HEATERS, B.T.U. PER POUND OF FEEDWATER:
246. C *** MFWT = ((TSL + MCMW) +
247. C *** (CNOA + MCMW) +
248. C *** (SLDA + MCPP + (SOPB + SORR) + (1.0 + BFFC)) +
249. C *** ((MPPM + SHFW) + MCMW + PBFM) -
250. C *** (CNLS + MCMW + ((SOPB + SORR) + (1.0 + BFFC)))/
251. C *** ((SOPB + SORR) + (1.0 + BFFC))
252. C *** MFWB = (MFWT + MFWT)/2.0
253. C *** RECALCULATE STEAM OUTPUT OF RECOVERY BOILER, POUNDS OF STEAM/DAY:
254. C *** SORR = (MSRB + 100000.0)/(MSHP - MFWB)
255. C *** RECALCULATE NET HIGH PRESSURE PROCESS STEAM DEMANDS, POUNDS/DAY:
256. C *** MPD = (MPPM + PPRD) + (MPTC + PPRD) +
257. C ***

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[illegible]

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498. 4.32X, 'MILLION POUNDS OF', 11X, 'HEAT ENERGY', 30X, 'STEAM', 9X,
499. 4.32X, 'PER DAY' PER HR. PER MR. PER TON'')
500. WRITE (6,210) 0(1,1),0(1,2),0(1,3),0(1,4),0(1,5),0(1,6),0(1,7),0(1,8),0(1,9),0(1,10),0(1,11),0(1,12),0(1,13),0(1,14),0(1,15),0(1,16),0(1,17),0(1,18),0(1,19),0(1,20),0(1,21),0(1,22),0(1,23),0(1,24),0(1,25),0(1,26),0(1,27),0(1,28),0(1,29),0(1,30),0(1,31),0(1,32),0(1,33),0(1,34),0(1,35),0(1,36),0(1,37),0(1,38),0(1,39),0(1,40),0(1,41),0(1,42),0(1,43),0(1,44),0(1,45),0(1,46),0(1,47),0(1,48),0(1,49),0(1,50),0(1,51),0(1,52),0(1,53),0(1,54),0(1,55),0(1,56),0(1,57),0(1,58),0(1,59),0(1,60),0(1,61),0(1,62),0(1,63),0(1,64),0(1,65),0(1,66),0(1,67),0(1,68),0(1,69),0(1,70),0(1,71),0(1,72),0(1,73),0(1,74),0(1,75),0(1,76),0(1,77),0(1,78),0(1,79),0(1,80),0(1,81),0(1,82),0(1,83),0(1,84),0(1,85),0(1,86),0(1,87),0(1,88),0(1,89),0(1,90),0(1,91),0(1,92),0(1,93),0(1,94),0(1,95),0(1,96),0(1,97),0(1,98),0(1,99),0(1,100),0(1,101),0(1,102),0(1,103),0(1,104),0(1,105),0(1,106),0(1,107),0(1,108),0(1,109),0(1,110),0(1,111),0(1,112),0(1,113),0(1,114),0(1,115),0(1,116),0(1,117),0(1,118),0(1,119),0(1,120),0(1,121),0(1,122),0(1,123),0(1,124),0(1,125),0(1,126),0(1,127),0(1,128),0(1,129),0(1,130),0(1,131),0(1,132),0(1,133),0(1,134),0(1,135),0(1,136),0(1,137),0(1,138),0(1,139),0(1,140),0(1,141),0(1,142),0(1,143),0(1,144),0(1,145),0(1,146),0(1,147),0(1,148),0(1,149),0(1,150),0(1,151),0(1,152),0(1,153),0(1,154),0(1,155),0(1,156),0(1,157),0(1,158),0(1,159),0(1,160),0(1,161),0(1,162),0(1,163),0(1,164),0(1,165),0(1,166),0(1,167),0(1,168),0(1,169),0(1,170),0(1,171),0(1,172),0(1,173),0(1,174),0(1,175),0(1,176),0(1,177),0(1,178),0(1,179),0(1,180),0(1,181),0(1,182),0(1,183),0(1,184),0(1,185),0(1,186),0(1,187),0(1,188),0(1,189),0(1,190),0(1,191),0(1,192),0(1,193),0(1,194),0(1,195),0(1,196),0(1,197),0(1,198),0(1,199),0(1,200),0(1,201),0(1,202),0(1,203),0(1,204),0(1,205),0(1,206),0(1,207),0(1,208),0(1,209),0(1,210),0(1,211),0(1,212),0(1,213),0(1,214),0(1,215),0(1,216),0(1,217),0(1,218),0(1,219),0(1,220),0(1,221),0(1,222),0(1,223),0(1,224),0(1,225),0(1,226),0(1,227),0(1,228),0(1,229),0(1,230),0(1,231),0(1,232),0(1,233),0(1,234),0(1,235),0(1,236),0(1,237),0(1,238),0(1,239),0(1,240),0(1,241),0(1,242),0(1,243),0(1,244),0(1,245),0(1,246),0(1,247),0(1,248),0(1,249),0(1,250),0(1,251),0(1,252),0(1,253),0(1,254),0(1,255),0(1,256),0(1,257),0(1,258),0(1,259),0(1,260),0(1,261),0(1,262),0(1,263),0(1,264),0(1,265),0(1,266),0(1,267),0(1,268),0(1,269),0(1,270),0(1,271),0(1,272),0(1,273),0(1,274),0(1,275),0(1,276),0(1,277),0(1,278),0(1,279),0(1,280),0(1,281),0(1,282),0(1,283),0(1,284),0(1,285),0(1,286),0(1,287),0(1,288),0(1,289),0(1,290),0(1,291),0(1,292),0(1,293),0(1,294),0(1,295),0(1,296),0(1,297),0(1,298),0(1,299),0(1,300),0(1,301),0(1,302),0(1,303),0(1,304),0(1,305),0(1,306),0(1,307),0(1,308),0(1,309),0(1,310),0(1,311),0(1,312),0(1,313),0(1,314),0(1,315),0(1,316),0(1,317),0(1,318),0(1,319),0(1,320),0(1,321),0(1,322),0(1,323),0(1,324),0(1,325),0(1,326),0(1,327),0(1,328),0(1,329),0(1,330),0(1,331),0(1,332),0(1,333),0(1,334),0(1,335),0(1,336),0(1,337),0(1,338),0(1,339),0(1,340),0(1,341),0(1,342),0(1,343),0(1,344),0(1,345),0(1,346),0(1,347),0(1,348),0(1,349),0(1,350),0(1,351),0(1,352),0(1,353),0(1,354),0(1,355),0(1,356),0(1,357),0(1,358),0(1,359),0(1,360),0(1,361),0(1,362),0(1,363),0(1,364),0(1,365),0(1,366),0(1,367),0(1,368),0(1,369),0(1,370),0(1,371),0(1,372),0(1,373),0(1,374),0(1,375),0(1,376),0(1,377),0(1,378),0(1,379),0(1,380),0(1,381),0(1,382),0(1,383),0(1,384),0(1,385),0(1,386),0(1,387),0(1,388),0(1,389),0(1,390),0(1,391),0(1,392),0(1,393),0(1,394),0(1,395),0(1,396),0(1,397),0(1,398),0(1,399),0(1,400),0(1,401),0(1,402),0(1,403),0(1,404),0(1,405),0(1,406),0(1,407),0(1,408),0(1,409),0(1,410),0(1,411),0(1,412),0(1,413),0(1,414),0(1,415),0(1,416),0(1,417),0(1,418),0(1,419),0(1,420),0(1,421),0(1,422),0(1,423),0(1,424),0(1,425),0(1,426),0(1,427),0(1,428),0(1,429),0(1,430),0(1,431),0(1,432),0(1,433),0(1,434),0(1,435),0(1,436),0(1,437),0(1,438),0(1,439),0(1,440),0(1,441),0(1,442),0(1,443),0(1,444),0(1,445),0(1,446),0(1,447),0(1,448),0(1,449),0(1,450),0(1,451),0(1,452),0(1,453),0(1,454),0(1,455),0(1,456),0(1,457),0(1,458),0(1,459),0(1,460),0(1,461),0(1,462),0(1,463),0(1,464),0(1,465),0(1,466),0(1,467),0(1,468),0(1,469),0(1,470),0(1,471),0(1,472),0(1,473),0(1,474),0(1,475),0(1,476),0(1,477),0(1,478),0(1,479),0(1,480),0(1,481),0(1,482),0(1,483),0(1,484),0(1,485),0(1,486),0(1,487),0(1,488),0(1,489),0(1,490),0(1,491),0(1,492),0(1,493),0(1,494),0(1,495),0(1,496),0(1,497),0(1,498),0(1,499),0(1,500),0(1,501),0(1,502),0(1,503),0(1,504),0(1,505),0(1,506),0(1,507),0(1,508),0(1,509),0(1,510),0(1,511),0(1,512),0(1,513),0(1,514),0(1,51
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176. WRITE (6,60) CAOL,NLP,PLRO
177. *FORMAT ('0.25,LINE BALANCE'//4X,'TIME CONSUMED IN SLAKING & CAUS
178. *TING',X,F8.2,X,'TONS/DAY'//4X,'TIME PRODUCED IN LIME KILN',
179. *1X,F8.2,X,'TONS/DAY'//4X,'PURCHASED MAKE-UP LIME',10X,F8.2,
180. *2X,'TONS/DAY'//)
181. *
182. WRITE (6,70) 9L8,SDBS,SDBSG,SDBR
183. *FORMAT ('0.25,SALTCAKE LOSSES'//4X,'NET SALTCAKE LOSSES',12X,
184. *F7.3,X,'TONS/DAY'//4X,'(EXCLUDING RECOVERY FROM POWER BOILER DESULFURIZING)',
185. *1X,F8.2,X,'TONS/DAY'//4X,'SALTCAKE RECOVERED IN POWER BOILER DESULFURIZING',
186. *13X,F7.3,X,'TONS/DAY'//10X,'BASED ON',1//
187. *10X,F7.3,X,'TONS/DAY'//4X,'REMOVAL RATIO'//
188. *10X,F7.3,X,'TONS/DAY'//4X,'PURCHASED SALTCAKE REQUIRED',4X,F7.3,X,X,
189. *IF (PSCR.GT.0.001) WRITE (6,80) PSCR
190. *IF (PSCR.GT.0.001) WRITE (6,80) PSCR
191. *TONS/DAY'//)
192. *
193. WRITE (6,90) CSDB
194. *FORMAT ('0.3X,SUPPLUS SALTCAKE PRODUCED',4X,F7.3,X,'TONS/DAY'//)
195. *
196. WRITE (6,100) CSDB
197. *FORMAT ('0.3X,CAUSTIC SODA (50 PCT. SODIUM HYDROXIDE)',4X,'REQUI
198. *RED FOR DESULFURIZING',5X,F7.3,X,'TONS CHEMICAL/DAY'//)
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15. C *** THIS IS THE LIST OF INPUTS:
16. C
17. C *** EPLF - EFFLUENT FLOW TO WASTEWATER TREATMENT FACILITIES OF
18. C MILL, GALLONS PER DRY TON OF PAPER OR PAPERBOARD PRODUCT.
19. C *** ETCH - EFFLUENT TREATMENT CHEMICALS (NUTRIENTS SUCH AS NITROGEN
20. C AND PHOSPHORUS COMPOUNDS) IN UNITS OF CHEMICALS (GALLONS,
21. C POUNDS, ETC.) PER THOUSAND GALLONS OF UNTREATED EFFLUENT.
22. C *** PETC - AVERAGE PRICE OF EFFLUENT TREATMENT CHEMICALS IN DOLLARS
23. C PER UNIT (GALLONS, POUNDS-ETC.).
24. C *** PMCH - AVERAGE PRICE OF FEEDWATER TREATMENT CHEMICALS PER UNIT OF
25. C CHEMICAL (DOLLARS PER POUND, GALLONS, ETC.).
26. C *** PMTR - PRICE OF MILL WATER, DOLLARS PER THOUSAND GALLONS OF WATER
27. C INPUT REQUIREMENTS.
28. C *** WATR - MILL WATER REQUIREMENTS, GALLONS PER DRY TON OF PAPER OR
29. C PAPERBOARD PRODUCT OUTPUT.
30. C *** MICH - WATER TREATMENT CHEMICALS REQUIRED, AVERAGE UNITS (POUNDS,
31. C GALLONS, ETC.) PER THOUSAND GALLONS OF WATER INTO MILL.
32. C
33. C *** READ STATEMENTS:
34. C
35. C READ (5,10) EPLF,ETCH,PETC,PMCH,PMTR,WATR,MICH
36. C 10 FORMAT (//7(20.0//))
37. C
38. C *** CALCULATIONS:
39. C
40. C *** CALCULATE TOTAL MILL WATER INPUT REQUIREMENTS, MILLIONS OF
41. C GALLONS PER DAY:
42. C TWMR = WATR * PROD/1000000.0
43. C *** CALCULATE MILL WATER TREATMENT CHEMICAL REQUIREMENTS IN UNITS OF
44. C CHEMICALS (GALLONS, POUNDS, ETC.) PER DAY:
45. C MTC = MICH * TWMR * 1000.0
46. C *** CALCULATE TOTAL EFFLUENT FLOW TO WASTEWATER TREATMENT, MILLIONS
47. C OF GALLONS PER DAY:
48. C TEFL = EPLF * PROD/1000000.0
49. C *** CALCULATE EFFLUENT TREATMENT CHEMICAL REQUIREMENTS IN UNITS OF
50. C CHEMICALS (GALLONS, POUNDS, ETC.) PER DAY:
51. C TETC = TEFL * ETCH * 1000.0
52. C END

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C *** BENEFITS AND RELATED EXPENSES, DOLLARS PER HOUR.
C *** PLNG - AVERAGE PROCESS LABOR WAGE RATE, INCLUDING ALL PRINGE
C *** BENEFITS AND RELATED EXPENSES, DOLLARS PER HOUR.
C *** PSLB - AVERAGE PROCESS LABOR REQUIREMENTS, NUMBER OF HOURLY WAGE
C *** PROCESS PERSONNEL NEEDED PER DAY (8-HOUR SHIFTS EACH).
C *** ROST - COST OF ROLL COVERS FOR FINISHED ROLLS OF PAPER OR PAPER-
C *** BOARD PRODUCT, DOLLARS PER DRY TON OF PRODUCT.
C *** MCST - COST OF WIRES FOR PAPER MACHINE, DOLLARS PER DRY TON OF
C *** PRODUCT.
C *** MPFS - COST OF NET FELTS FOR PAPER MACHINE, DOLLARS PER DRY TON
C *** OF PRODUCT.
C ***
C *** READ STATEMENTS:
C ***
C *** READ ($,1) AMLB,AMWG,CCTC,CFMC,OFCS,DPYR,EVLB,EXMG,PLNG,PSLB,RCST,
C *** MCST,MPCS
C *** 1 FORMAT (//12(P20.0//),F20.0)
C ***
C *** CALCULATIONS:
C ***
C *** CALCULATE MILL REVENUES, DOLLARS PER DAY, FOR PAPER (BOARD),
C *** TURPENTINE, "BOARD", SURPLUS ELECTRICAL ENERGY, EXCESS RECLAIMED
C *** SALTCAKE, SURPLUS BARK:
C *** R(1,1) = SVAL * PPRD
C *** R(2,1) = TSPV * TPRD
C *** R(3,1) = SOPP * SOPR
C *** R(4,1) = SVSE * SREE
C *** R(5,1) = SVSC * SSCK
C *** R(6,1) = (MPC * 0.5) * SURB
C *** CALCULATE FUEL AND ENERGY COSTS, DOLLARS PER DAY, FOR COAL, WOOD
C *** FUEL, NATURAL GAS, ELECTRICAL ENERGY:
C *** VC(1,1) = CMPC * GCOL
C *** VC(2,1) = MPKC * GHOD
C *** VC(3,1) = PPKF * TKPR
C *** VC(4,1) = PPMW * PERG
C *** CALCULATE PULPWOOD AND RECYCLED FIBER RAW MATERIAL COSTS, DOLLARS
C *** FOR SOUTHWOOD ROUNDWOOD, MAPWOOD ROUNDWOOD, SOUTHWOOD "CLEAN" CHIPS,
C *** HARDWOOD "CLEAN" CHIPS, SOUTHWOOD WHOLE-TREE CHIPS, HARDWOOD WHOLE
C *** TREE CHIPS, RECYCLED OLD CORRUGATED, AND RECYCLED PAPER:
C *** VC(5,1) = PRPW * CDSH
C *** VC(6,1) = PRHW * CDHW
C *** VC(7,1) = PRPC * SCCH
C *** VC(8,1) = PMPC * MCKC
C *** VC(9,1) = PMWC * SHCW
C *** VC(10,1) = PMHC * MNCW
C *** VC(11,1) = PCOR * RCRT
C *** VC(12,1) = PCOR * RCRT
C *** VC(13,1) = PPAP * RPPT
C *** CALCULATE COSTS OF ADDITIVES IN STOCK PREPARATION, DOLLARS PER
C *** DAY, FOR ALUM, SULFURIC ACID, STARCH, DEFOAMER, ROSIN, SLIMICIDE:
C *** VC(14,1) = PALM * TALM
C *** VC(15,1) = PACO * TACO
C *** VC(16,1) = PSTC * YSTC
C *** VC(17,1) = PDPH * TDFH
C *** VC(18,1) = PRSH * TRSH
C *** VC(19,1) = PRLM * TBLM
C *** CALCULATE COSTS OF MAKE-UP AND RECLAIM CHEMICALS FOR HEART
C *** PROCESS, DOLLARS PER DAY, FOR SALTCAKE, LIME, CAUSTIC SODA FOR
C *** SALTCAKE RECLAIM:
C *** VC(19,1) = PRPC * PSRC
C *** VC(20,1) = PPLM * PLNG
C *** VC(21,1) = PCAS * CSBS
C *** CALCULATE COSTS OF OTHER MISCELLANEOUS CHEMICALS, DOLLARS PER
C *** DAY, FOR COOLING TOWER, BOILER FEEDWATER, MILL WATER TREATMENT,
C *** EFFLUENT TREATMENT:
C *** VC(20,1) = CCTC * PPRD
C *** VC(21,1) = CFPC * PPRD
C *** VC(22,1) = PMCW * TMCW
C *** VC(23,1) = PETC * TETC
C *** CALCULATE OTHER VARIABLE COSTS, DOLLARS PER DAY, FOR ROLL COVERS,
C *** WIRES, NET FELTS, COVER FELTS, MILL WATER SUPPLY:
C *** VC(23,1) = RCST * PPRD
C *** VC(24,1) = MPCS * PPRD
C *** VC(25,1) = DPFS * PPRD
C *** VC(26,1) = PMTW * (TMRH/1000.0)
C *** CALCULATE LABOR COSTS, DOLLARS PER DAY, FOR PROCESS LABOR, NON-
C *** PROCESS LABOR, AND MAINTENANCE:

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113. VC(27,1) = PSLB * PLNG * 0.0
114. VC(28,1) = XLN * ENMG * 0.0
115. VC(29,1) = AMLB * AMNG * 0.0
C *** CALCULATE REVENUES IN DOLLARS PER TON OF PRODUCT AND PER YEAR:
116. DO 2 I = 1,6
117. R(1,2) = R(1,1)/PPRD
R(1,3) = R(1,1) * DPVR
119.
2. CONTINUE
C *** CALCULATE COSTS IN DOLLARS PER TON OF PRODUCT AND PER YEAR:
120. DO 3 I = 1,33
121. VC(1,2) = VC(1,1)/PPRD
122. VC(1,3) = VC(1,1) * DPVR
123.
3. CONTINUE
C *** ASSIGN PRICE-PER-UNIT-OF-VARIABLE INPUT DATA:
124. R(1,4) = SVAL
R(2,4) = TFSV
126. R(3,4) = SOPP
127. R(4,4) = SVSE
128. R(5,4) = SVSC
129. R(6,4) = WPRC * 0.5
130. VC(11,4) = CPRC
131. VC(12,4) = WPRC
132. VC(13,4) = PPKF
133. VC(14,4) = PKMH
134. VC(15,4) = PSRM
135. VC(16,4) = PSRC
136. VC(17,4) = PRCM
137. VC(18,4) = PRC
138. VC(19,4) = PALM
139. VC(10,4) = PACO
140. VC(11,4) = PSTC
141. VC(12,4) = PDFM
142. VC(13,4) = PRSN
143. VC(14,4) = PSLM
144. VC(15,4) = PPSL
145. VC(16,4) = PPLM
146. VC(17,4) = PCAJ
147. VC(18,4) = PMCH
148. VC(19,4) = PETC
149. VC(20,4) = PMTR
150. VC(21,4) = PLUG
151. VC(22,4) = ENMG
152. VC(23,4) = AMNG
153. VC(24,4) = PMSC
154. VC(25,4) = PCOR
155. VC(26,4) = PPAP
156. VC(27,4) = P(10)
157.
10. FORMAT (11,'5X','R E V E N U E S, C O S T S, P R O F I T C O
      * N A T I O N A L I T Y I N $'//)
158. WRITE (6,20) (R(1,4),R(11,4),R(12,4),R(13,4),I=1,3)
20. FORMAT ('01,'51X,'$DAY',3X,'$ANNUAL',11X,'REVENUES
      * $11X,'PAPERBOARD PRODUCT' (0 $1,'F6.2','/DRY TON'),9X,'F10.0,'F9.2,
      * $12.01X,
      * 'PULPWOOD' (0 $1,'F6.2','/GALLON'),10X,'F10.0,'1X,'F9.2,
      * $12.01X,
      * $1X,'TALL OIL SNAP' (0 $1,'F6.2','/TON'),3X,'10X,'F10.0,'1X,'F9.2,
      * $12.01X,
      * IF (SNEE.GT.0.1) WRITE (6,30) R(4,4),R(4,1),R(5,2),R(4,3)
30. FORMAT ('1','SURPLUS COGEN. ELECTRIC (0 $1,'F6.3','/KWH'),9X,'F10.0,
      * $1X,'F8.2,'F12.0)
      * IF (SCKM.GT.0.1) WRITE (6,40) R(5,1),R(5,2),R(5,3)
40. FORMAT ('1','EXCESS RECLAIM SALTCAKE (0 $1,'F6.2','/TON'),9X,'F10.0,
      * $1X,'F8.2,'F12.0)
      * IF (SFB.GT.0.1) WRITE (6,50) R(6,1),R(6,2),R(6,3)
50. FORMAT ('1','SURPLUS WOOD FUEL (0 1/2 FUEL PRICE,$1,'F6.2','/TON'),
      * $1X,'F10.0,'1X,'F8.2,'F12.0)
      * DO 55 I = 1,3
      * R(7,1) = R(1,1) + R(2,1) + R(3,1) + R(4,1) + R(5,1) + R(6,1)
55. CONTINUE
      * WRITE (6,56) R(7,1),R(7,2),R(7,3)
56. FORMAT ('01,'$1X,'TOTAL REVENUES',30X,'F10.0,'F9.2,'F12.0)
      * WRITE (6,60)
60. FORMAT ('01,'31X,'PULPWOOD COSTS'//)
      * IF (CDHM.GT.0.0001) WRITE (6,57) VC(5,4),VC(5,1),VC(5,2),VC(5,3)
      * IF (CDHM.GT.0.0001) WRITE (6,58) VC(6,4),VC(6,1),VC(6,2),VC(6,3)
57. FORMAT ('1','SOFTWOOD ROUNDWOOD (0 $1,'F6.2','/CORD'),13X,'F10.0,
      * $F9.2,'F12.0)

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END

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